Full vs. Light-Handed Regulation of a Network Industry

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February 2004
Preliminary and incomplete. Please do not quote.

Abstract

The access pricing problem emerges when a vertically integrated firm (the incumbent) provides an essential service in the upstream market, to an entrant. Both firms produce a final service and compete in the downstream market. The standard treatment of this problem has been to add the access price to the list of instruments available to a regulator who maximizes a social welfare function. Motivated by the international trend to reduce the number of prices set by regulation, we use a light handed regulation approach in which the only tool available to the regulator is the access price, and where retail prices are set by quantity competition in the downstream market. In this setup, we find that a regulator seeking to maximize total market surplus will set an access price that subsidizes the entrant, so that entrants that are less efficient than the incumbent firm can survive in the market. We then compare the outcomes of the full regulation model with those of the light-handed regulation model, in terms of final prices, firm profits, and consumer surplus. When the regulator faces incomplete information about entrant firms' costs and cannot offer a menu of contracts to potential entrants, we find examples in which light handed regulation can dominate full regulation.

1 Introduction and Motivation

The access pricing problem arises when a vertically integrated multiproduct firm (the incumbent) provides an essential input (e.g., local telephone network) to another firm (the entrant) which produces a final or retail service with it (e.g., long distance telephone service). The incumbent also uses the essential input to provide a retail service that may be different from the entrant's. Hence, while the entrant is a client of the incumbent at the input level, it is a competitor at the final service level. It is usually assumed that the essential service has natural monopoly characteristics, hence, price(s) of access to the network are regulated. In practice, this problem has become increasingly common as many countries have opened some segments of network industries to competition (e.g. long distance telephony, electricity generation).

The standard treatment of the access pricing problem in the literature is to incorporate the price of the essential intermediate good into a scheme of regulation that uses prices, quantities, cost levels, and transfers as instruments. In this context, the access price will reflect the marginal cost of the network, as well as a contribution to covering the fixed costs of the network. In addition, if the regulator faces asymmetric information about the incumbent's cost structure, the access price will contain part of the informational rents provided to induce truthful revelation of costs.[1] An important and much discussed access pricing rule is the efficient component pricing rule (ECPR), which roughly states that the access price must compensate the incumbent for the opportunity costs of access.[2]. The ECPR generally precludes entry when potential entrants are less efficient than the incumbent firm. Critics of this rule (e.g. Economides and White 1995,1998) have argued that competition provides benefits that may make even less efficient entrants desirable.

From our perspective there are two main objections to this dominant approach to the access pricing problem. First, competition itself does not provide benefits, and only increases social welfare or surplus if the entrant(s) are more technically efficient than the incumbent firm. Second, in practice we do not observe regulators having access (or using) such a wide array of regulatory instruments as are used in the literature on regulation. In fact, regulators have been moving towards schemes in which they use fewer instruments. For example, New Zealand has adopted a regime of no direct regulation of access prices or final prices, and relies entirely on competition law to avoid abuse, collusion, or discrimination in access pricing negotiations.[3] In Australia, the regulatory authority does not set final prices, and competitors negotiate the access price. The regulator only intervenes if negotiations break down. A similar setup prevails in the US.[4].

This paper attempts to deal with these objections first by considering a model in which the regulator only sets the price at which an incumbent firm sells an essential intermediate input to a potential entrant to the market. In this setup we find that the access price will have very different characteristics as compared with a regulatory framework in which access price is used as one of several regulatory instruments. In

[1] For a general treatment of the access pricing problem in this vein see Laffont and Tirole (1994).
[2] See Baumol and Sidak (1995).
[3] See Economides (1999).
[4] See Economides (1998).

particular, we find that the access price may not cover the marginal cost of producing the intermediate good (operating the network), thereby providing a subsidy to the entrant firm. In general, the regulator will oblige the incumbent firm to provide a greater subsidy to the entrant as the entrant firm becomes more efficient.[5]

Our second goal is to compare total market surplus under a light handed regulatory regime, in which only the access price is set by the regulator, with respect to a fully regulated regime, in which the access price and final quantities sold in the downstream market are determined by regulation. If there are situations in which light handed regulation dominates, then there may be theoretical justification for the observed shift towards fewer regulatory instruments. In the context of this second objective, we make two crucial assumptions. First, the regulator does not have perfect information about the cost structure of potential entrants; and second, the regulator can offer a menu of regulatory contracts to the incumbent firm, but not to the potential entrant. This assumption is equivalent to forcing the regulator to use all the instruments at her disposal. For example, if there is only one type of incumbent, only one contract of access price and final quantities can be offered under full regulation; it is not possible to set only the access price and provide alternative sets of quantities for each available access price. In other words, we assume that if legislation provides the regulator with a particular instrument, this may not imply wide discretion in the use (or non-use) of the instrument.

There is some evidence that courts can read regulatory statutes narrowly in order to reduce the discretion a regulator has in the use of its regulatory instruments. Also, courts tend to overturn sections of statutes that appear to grant unchecked discretion to administrative agencies. An important case in this respect is *MCI Telecommunications Corp. vs. AT & T Co.(1994)*,[6] in which the US Supreme Court ruled that the Federal Communications Commission could not allow non-dominant firms to stop posting their rates, even though the relevant statute provided for modifications to the rate posting process to be made by the FCC at its own discretion.

Given these assumptions, we find that full regulation always dominates light handed regulation, from the social perspective, when there is no uncertainty about the entrant's cost structure. However, with uncertainty about potential entrants' costs, light handed regulation may dominate full regulation. We cannot yet characterize generally the situations in which this result holds. However we provide some examples, with or without an intermediate good and with or without asymmetric information about the incumbent firm's costs, in which light handed regulation can dominate.

The rest of the paper is organized as follows. Section 2 provides a basic model in which firms may compete in Cournot fashion in the downstream market, or quantities can be set by regulation. We compare access pricing rules under the two regimes derived by unconstrained total surplus optimization with perfect information. Section

[5] Our results in this regard are very similar to those of Lewis and Sappington (1999).

[6] 512 U.S. 218.

3 compares the outcomes of full and light handed regulation under asymmetric and incomplete information about incumbent and entrant costs, respectively. Section 4 concludes.

2 Basic Model

We consider a model with only two firms, the incumbent and a potential entrant. The incumbent is a vertically integrated firm that produces an essential intermediate good (such as a local distribution network), which it uses to produce a final good or service. An entrant to this market must purchase the intermediate good from the incumbent firm in order to produce the final good. We assume that the intermediate good is not sold directly to consumers; it is only used by the incumbent and entrant firms to produce their final goods. For each unit of final good it wishes to produce, each firm needs exactly one unit of the intermediate good. The access price is the price at which the incumbent sells the intermediate good to the entrant.

A regulator in this market seeks to maximize total surplus from the market, defined as the (unweighted) sum of net consumer surplus and the profits of firms in the market. We consider two regulatory regimes: "full regulation", in which the regulator sets the access price and the quantities produced by each firm in the final market, and "light handed regulation" in which the regulator sets only the access price. In the latter regulatory environment, we assume that firms compete setting quantities simultaneously in the final market.

Regulatory interaction is often modeled as a problem of asymmetric information. We consider situations in which the regulator has perfect information about the incumbent's cost function, as well as situations in which the incumbent firm has private information about its costs. With respect to the entrant's costs, we generally assume that the regulator has incomplete information. The potential entrant holds private information about its costs. However, we allow the regulator to offer a menu of access prices and quantities to the incumbent, but not to the potential entrant. Hence, incompleteness of information regarding the entrant's costs cannot be addressed by standard contracting techniques to solve problems of adverse selection.

Under full regulation, the regulator faces a participation constraint for each firm. In particular, we assume that the regulator cannot set the quantity of either firm to be strictly positive, at a market price that results in negative profits for the firm. When the regulator faces asymmetric information about the incumbent's costs, it may offer a menu of contracts to this firm in order to induce truthful revelation of costs. In this case, the menu of contracts must satisfy incentive compatibility for each possible type of incumbent. With respect to the entrant, we assume that the regulator faces incomplete information, i.e. she does not know the cost function of the potential entrant. Moreover, we assume that the regulator cannot contract with the potential entrant. This means that for any set of quantities and access price set by the regulator and chosen in equilibrium by some type of the incumbent firm, any possible type of entrant must have non-negative profits.

Under light handed regulation, the regulator sets only the access price, and firms interact a la Cournot in the downstream market. The regulator's problem is solved by backward induction; she sets the access price(s) to maximize total surplus from the market, given the effects of the access price on the outcomes of quantity competition in the downstream market. Again the regulator faces a participation constraint for both firms. Faced with asymmetric information about the incumbent firm's costs, the regulator can offer a menu of contracts to induce truthful revelation by the incumbent. In this case, each type of incumbent choosing the contract designed for his type must have non-negative profits. In addition, the set of contracts offered must satisfy incentive compatibility for the incumbent. With respect to the entrant, given incomplete information, the market outcomes resulting from each access price chosen by some type of the incumbent in equilibrium must include non negative profits for each possible type of entrant.

2.1 Assumptions

Inverse demand is given by

$$P = a - bQ; Q = q_1 + q_2.$$

There are two firms, the incumbent (1) and the entrant (2).

The firms sell homogeneous products in the downstream market.

Costs are given by

$$C_i = c_i q_i, i = 1, 2$$

We assume there are only two possible types of each firm. In particular, $c_1 \in \left\{\underline{c_1}, \overline{c_1}\right\}$; $c_2 \in \left\{\underline{c_2}, \overline{c_2}\right\}$, where $\underline{c_1} < \overline{c_1}$ and $\underline{c_2} < \overline{c_2}$.

The lower cost realizations of incumbent and entrant occur with probabilities α and β, respectively.

For each unit of q_i produced, one unit of q_0 is required. The costs incurred by firm 1 in production of the intermediate good are

$$C_0 = c_0 q_0 = c_0 \left(q_1 + q_2\right)$$

The value of c_0 is known to the regulator and to both firms. For each unit of this intermediate good purchased by the entrant, the incumbent firm charges t.

Firm profits are given by:

$$\pi_1 = \left(a - bq_1 - bq_2 - c_0 - c_1\right) q_1 + \left(t - c_0\right) q_2 \tag{1}$$

$$\pi_2 = \left(a - bq_1 - bq_2 - t - c_2\right) q_2 \tag{2}$$

Net consumer surplus in this framework is given by

$$NCS = \frac{b\left(q_1+q_2\right)^2}{2} \tag{3}$$

The regulator's objective is to maximize total surplus, given by

$$TS = NCS + \pi_1 + \pi_2 \tag{4}$$

2.2 Comparison of access rules: Perfect information, no participation constraints.

To illustrate the difference between the optimal access prices under full and light handed regulation, we first examine a special case of the model above, with perfect information about both firms' cost parameters, and no participation constraints for either firm. In this subsection assume that $\underline{c_1} = \overline{c_1} = c_1$ and $\underline{c_2} = \overline{c_2} = c_2$. The assumption of perfect information will clearly result in full regulation dominating light handed regulation from the social perspective, particularly because light handed regulation includes imperfect competition between the firms in the downstream market. Assuming that the regulator need not satisfy a budget constraint even for the incumbent firm implies that under light handed regulation, the regulator can set the access price very low in order to induce tougher competition between the entrant and the incumbent firms. This assumption, while unrealistic, will make the difference between optimal access pricing under the two regimes particularly stark.

Under full regulation, the regulator faces the following problem

$$\underset{t,q_1,q_2}{Max}\ \left(a-bq_1-bq_2-c_0-c_1\right)q_1+\left(t-c_0\right)q_2+\left(a-bq_1-bq_2-t-c_2\right)q_2+\frac{b\left(q_1+q_2\right)^2}{2} \tag{5}$$

Note that here the regulator will be indifferent with regard to the value of t, as it represents a transfer from the entrant to the incumbent firm. To solve this problem the regulator will select only one firm to produce, unless $c_1 = c_2$, in which case the regulator will set a market price and will be indifferent as to the proportions of the market served by each firm. Although the access price here is irrelevant to the determination of total surplus, we can assume that the regulator will set t in order to maintain zero profits for the entrant whether or not its quantity is set to be positive. Hence $t = c_0$. This outcome is identical to the result of perfect competition in the downstream market, with two available technologies, c_1 and c_2.

Under light handed regulation, the regulator sets only t and both firms take this access price as given and compete in Cournot fashion in the downstream market. Best response functions for the two firms will be:

$$q_1 = \frac{a-bq_2-c_0-c_1}{2b};\, q_2 = \frac{a-bq_1-t-c_2}{2b} \tag{6}$$

Solving simultaneously results in

$$q_1 = \frac{a + t + c_2 - 2c_0 - 2c_1}{3b}; q_2 = \frac{a - 2t - 2c_2 + c_0 + c_1}{3b} \tag{7}$$

$$Q = \frac{2a - c_0 - c_1 - c_2 - t}{3b}; P = \frac{1}{3}\left(a + c_0 + c_1 + c_2 + t\right) \tag{8}$$

The regulator's problem is now:

$$\underset{t}{Max}\ \left(P - c_0 - c_1\right) q_1 + \left(t - c_0\right) q_2 + \left(P - t - c_2\right) q_2 + \frac{b\left(\frac{2a - c_0 - c_1 - c_2 - t}{3b}\right)^2}{2}$$

where P, q_1, q_2 are given by equations 7 and 8

The optimal access price is given by

$$t = -a + 5c_2 + 2c_0 - 4c_1$$

and total surplus is then

$$\frac{1}{2}\frac{3c_1^2 - 6c_1c_2 + 4c_2^2 + a^2 - 2ac_2 - 2ac_0 + 2c_2c_0 + c_0^2}{b}$$

Quantities produced in the downstream market will be

$$q_1 = \frac{2\left(c_2 - c_1\right)}{b}; q_2 = \frac{a - c_0 + 3c_1 - 4c_2}{b}$$

Note that in this regulatory regime the access price can be less than the marginal cost of producing the intermediate good, i.e.

$$t < c_0 \Longleftrightarrow c_0 + 5c_2 - 4c_1 < a$$

For example, if two firms are equally efficient in the downstream market ($c_1 = c_2 = c$), and the market is economically viable ($c_0 + c < a$), then the entrant will be provided with a subsidy in the form of an access price that does not cover the incumbent's marginal cost of producing the intermediate good. Also notice that the incumbent firm only produces a strictly positive quantity when it is more efficient than the entrant in the downstream segment. On the other hand, the entrant will produce a strictly positive quantity when its costs in the downstream market are equal to the incumbent's. To illustrate this result, we graph, for a given value of c_0, the condition that determines whether the access price will imply a subsidy to the entrant firm or not, and the conditions for which each firm will produce a positive quantity. Figure 1 below shows these conditions for $a = 1, b = 1, c_0 = 0.3$.

The triangle outlined by the heavy black lines is the area in which both firms produce positive quantities under this light handed regulation scheme with perfect

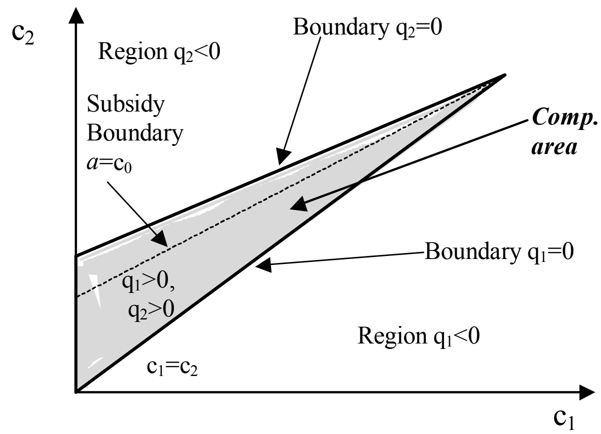

Figure 1:

information and without constraints. Outside this area only one of the firms will produce. The dotted line inside the triangle shows the values of the firms' cost parameters for which the access price will exactly equal the marginal cost of producing the intermediate good. Below this line the regulator will set an access price below the marginal cost, thus subsidizing the entrant's production. The intuition is simple: with the access price as her only tool, the regulator can only increase total quantity produced in the market by making the entrant more competitive. Reducing the access price diminishes the entrant's costs of production and makes him behave more aggressively in Cournot competition with the incumbent firm. This reduces the market price and increases the total quantity produced in the market. However, this policy tilts production towards the entrant, which is socially costly when the entrant is less efficient than the incumbent at producing the final good. For this reason the subsidy is reduced (access price increased) as the entrant becomes less efficient or as the incumbent becomes more efficient. The optimal access price set by the regulator results from the trade-off between the efficiency loss from having a less efficient firm produce and the efficiency gain from higher total production.

3 Full vs. light handed regulation under asymmetric and incomplete information

We now consider the problem of a regulator under each of the full and light handed regulatory regimes, given that the regulator may not know the type of the incumbent or entrant firms. In this setup, the incumbent and the entrant hold private information about their respective cost parameters, and both firms as well as the regulator know the probability distribution over cost parameters. In terms of constraints, we assume that the regulator must satisfy individual rationality (participation) constraints for both firms, and if she chooses to offer separating regulatory contracts, she must satisfy incentive compatibility constraints for each type of incumbent firm.

We set up the regulator's problem under each of these regimes. Then for the special case where both incumbent and regulator know the cost parameter of any potential entrant, we show that full regulation will dominate light handed regulation. This result can also be shown in a much more general model that does not specify demand functions, cost functions, or homogeneity of downstream goods.

Next we will argue that the proposition of full regulation dominance cannot be proven when the regulator has incomplete information about the entrant's costs, and when it cannot offer the entrant menus of regulatory contracts. Since no contracting is possible with the potential entrant, the best mechanism the regulator has to extract social surplus from the entrant is market interaction. Under some parameter settings, the value of this information is greater than the additional informational rents the regulator must give away to the low cost incumbent due to the reduced number of instruments for contracting with the incumbent. We include several examples to show situations in which light handed regulation does (or does not) dominate full regulation.

3.1 Regulator's problem

When setting the access price as well as the final goods prices, the regulator seeks to maximize the expected total surplus as follows:

$$\underset{\underline{t},\underline{q_1},\underline{q_2},\overline{t},\overline{q_1},\overline{q_2}}{Max} \alpha \left\{ \begin{array}{c} \left(a - b\underline{q_1} - b\underline{q_2} - c_0 - \underline{c_1}\right)\underline{q_1} + \left(\underline{t} - c_0\right)\underline{q_2} \\ +\beta\left(a - b\underline{q_1} - b\underline{q_2} - \underline{t} - \underline{c_2}\right)\underline{q_2} \\ +\left(1-\beta\right)\left(a - b\underline{q_1} - b\underline{q_2} - \underline{t} - \overline{c_2}\right)\underline{q_2} + \frac{b\left(\underline{q_1}+\underline{q_2}\right)^2}{2} \end{array} \right\}$$
$$+\left(1-\alpha\right)\left\{ \begin{array}{c} \left(a - b\overline{q_1} - b\overline{q_2} - c_0 - \overline{c_1}\right)\overline{q_1} + \left(\overline{t} - c_0\right)\overline{q_2} + \beta\left(a - b\overline{q_1} - b\overline{q_2} - \overline{t} - \underline{c_2}\right)\overline{q_2} \\ +\left(1-\beta\right)\left(a - b\overline{q_1} - b\overline{q_2} - \overline{t} - \overline{c_2}\right)\overline{q_2} + \frac{b\left(\overline{q_1}+\overline{q_2}\right)^2}{2} \end{array} \right\} \tag{9}$$

subject to:

Individual rationality constraints for incumbent

$$\left(a - b\underline{q_1} - b\underline{q_2} - c_0 - \underline{c_1}\right)\underline{q_1} + \left(\underline{t} - c_0\right)\underline{q_2} \geqslant 0 \tag{10}$$

$$\left(a - b\overline{q_1} - b\overline{q_2} - c_0 - \overline{c_1}\right)\overline{q_1} + \left(\overline{t} - c_0\right)\overline{q_2} \geqslant 0 \tag{11}$$

Incentive compatibility constraints for incumbent

$$\left(a - b\underline{q_1} - b\underline{q_2} - c_0 - \underline{c_1}\right)\underline{q_1} + \left(\underline{t} - c_0\right)\underline{q_2} \geqslant \left(a - b\overline{q_1} - b\overline{q_2} - c_0 - \underline{c_1}\right)\overline{q_1} + \left(\overline{t} - c_0\right)\overline{q_2} \tag{12}$$

$$\left(a - b\overline{q_1} - b\overline{q_2} - c_0 - \overline{c_1}\right)\overline{q_1} + \left(\overline{t} - c_0\right)\overline{q_2} \geqslant \left(a - b\underline{q_1} - b\underline{q_2} - c_0 - \overline{c_1}\right)\underline{q_1} + \left(\underline{t} - c_0\right)\underline{q_2} \tag{13}$$

Individual rationality constraints for entrant

$$\left(a - b\underline{q_1} - b\underline{q_2} - \underline{t} - \underline{c_2}\right)\underline{q_2} \geqslant 0$$

$$\left(a - b\underline{q_1} - b\underline{q_2} - \underline{t} - \overline{c_2}\right)\underline{q_2} \geqslant 0$$

$$\left(a - b\overline{q_1} - b\overline{q_2} - \overline{t} - \underline{c_2}\right)\overline{q_2} \geqslant 0$$

$$\left(a - b\overline{q_1} - b\overline{q_2} - \overline{t} - \overline{c_2}\right)\overline{q_2} \geqslant 0 \tag{14}$$

Call the solution to this problem

$$TS^*\left(\underline{t}, \underline{q_1}, \underline{q_2}, \overline{t}, \overline{q_1}, \overline{q_2}\right)$$

In a light handed regulation scheme, the regulator solves for the access price(s) that will maximize expected total surplus given that firms interact in Cournot fashion in the second stage of the game. As shown above for the case of perfect information, quantities and price will be given by equations 7 and 8, and profits and net consumer surplus will be

$$\begin{aligned}\pi_1(t, c_1, c_2) &= \left(\frac{1}{3}(a + c_0 + c_1 + c_2 + t) - c_0 - c_1\right)\left(\frac{a + t + c_2 - 2c_0 - 2c_1}{3b}\right) \\ &\quad + (t - c_0)\left(\frac{a - 2t - 2c_2 + c_0 + c_1}{3b}\right)\end{aligned}$$

$$\pi_2(t, c_1, c_2) = \left(\frac{1}{3}(a + c_0 + c_1 + c_2 + t) - t - c_2\right)\left(\frac{a - 2t - 2c_2 + c_0 + c_1}{3b}\right)$$

$$NCS(t, c_1, c_2) = \frac{b\left(\frac{2a - c_0 - c_1 - c_2 - t}{3b}\right)^2}{2}$$

where

$$t \in \left\{\underline{t}, \overline{t}\right\}; c_1 \in \left\{\underline{c_1}, \overline{c_1}\right\}; c_2 \in \left\{\underline{c_2}, \overline{c_2}\right\}$$

The regulator will now face the problem

$$\underset{\underline{t},\overline{t}}{Max}\ \alpha \left\{ \begin{array}{c} \beta\left[\pi_1\left(\underline{t},\underline{c_1},\underline{c_2}\right)+\pi_2\left(\underline{t},\underline{c_1},\underline{c_2}\right)+NCS\left(\underline{t},\underline{c_1},\underline{c_2}\right)\right] \\ +\left(1-\beta\right)\left[\pi_1\left(\underline{t},\underline{c_1},\overline{c_2}\right)+\pi_2\left(\underline{t},\underline{c_1},\overline{c_2}\right)+NCS\left(\underline{t},\underline{c_1},\overline{c_2}\right)\right] \end{array} \right\}$$

$$+\left(1-\alpha\right)\left\{ \begin{array}{c} \beta\left[\pi_1\left(\overline{t},\overline{c_1},\underline{c_2}\right)+\pi_2\left(\overline{t},\overline{c_1},\underline{c_2}\right)+NCS\left(\overline{t},\overline{c_1},\underline{c_2}\right)\right] \\ +\left(1-\beta\right)\left[\pi_1\left(\overline{t},\overline{c_1},\overline{c_2}\right)+\pi_2\left(\overline{t},\overline{c_1},\overline{c_2}\right)+NCS\left(\overline{t},\overline{c_1},\overline{c_2}\right)\right] \end{array} \right\} \quad (15)$$

subject to
individual rationality constraints for incumbent

$$\pi_1\left(\underline{t},\underline{c_1},\underline{c_2}\right)\geqslant 0;\pi_1\left(\underline{t},\underline{c_1},\overline{c_2}\right)\geqslant 0;\pi_1\left(\overline{t},\overline{c_1},\underline{c_2}\right)\geqslant 0;\pi_1\left(\overline{t},\overline{c_1},\overline{c_2}\right)\geqslant 0 \quad (16)$$

incentive compatibility constraints for incumbent

$$\beta\left(\pi_1\left(\underline{t},\underline{c_1},\underline{c_2}\right)\right)+\left(1-\beta\right)\pi_1\left(\underline{t},\underline{c_1},\overline{c_2}\right)\geqslant\beta\left(\pi_1\left(\overline{t},\underline{c_1},\underline{c_2}\right)\right)+\left(1-\beta\right)\pi_1\left(\overline{t},\underline{c_1},\overline{c_2}\right) \quad (17)$$

$$\beta\left(\pi_1\left(\overline{t},\overline{c_1},\underline{c_2}\right)\right)+\left(1-\beta\right)\pi_1\left(\overline{t},\overline{c_1},\overline{c_2}\right)\geqslant\beta\left(\pi_1\left(\underline{t},\overline{c_1},\underline{c_2}\right)\right)+\left(1-\beta\right)\pi_1\left(\underline{t},\overline{c_1},\overline{c_2}\right) \quad (18)$$

individual rationality constraints for entrant

$$\pi_2\left(\underline{t},\underline{c_1},\underline{c_2}\right)\geqslant 0;\pi_2\left(\underline{t},\underline{c_1},\overline{c_2}\right)\geqslant 0;\pi_2\left(\overline{t},\overline{c_1},\underline{c_2}\right)\geqslant 0;\pi_2\left(\overline{t},\overline{c_1},\overline{c_2}\right)\geqslant 0 \quad (19)$$

Call the solution to this problem

$$TS^*\left(\underline{t},\overline{t}\right)$$

3.2 No uncertainty about entrant: full regulation dominates

When the regulator knows the cost parameter of the potential entrant, she can extract the social benefits of entry by setting the entrant's quantity adequately as a function of his cost parameter. In other words, the only obstacle to replicating the competitive outcome through regulation is now the private information held by the incumbent. Given that the regulator can contract with the incumbent, the more variables the regulator can set in the contract, the more cheaply she can extract the incumbent's private information. In this regard we make the following proposition.

Proposition 1 $\underline{c_2}=\overline{c_2}=c_2$ *and* $\underline{c_1}<\overline{c_1}\Longrightarrow TS^*\left(\underline{t},\underline{q_1},\underline{q_2},\overline{t},\overline{q_1},\overline{q_2}\right)>TS^*\left(\underline{t},\overline{t}\right)$

Proof. *Consider a contract* $\left(\underline{t},\overline{t}\right)$ *that solves the regulator's problem under the light handed regime. Given* $\underline{c_2}=\overline{c_2}=c_2$*, we can define* $\left(\underline{q_1},\underline{q_2}\right)$ *and* $\left(\overline{q_1},\overline{q_2}\right)$ *as the results of Cournot competition between the incumbent of type* $\underline{c_1}$ *and type* $\overline{c_1}$ *and the entrant, respectively. Note that even if* $\underline{t}=\overline{t}$, $\left(\underline{q_1},\underline{q_2}\right)\neq\left(\overline{q_1},\overline{q_2}\right)$ *because each incumbent* *type will play the best response function corresponding to its true type. Now suppose the regulator offers the contracts* $\left(\underline{t}, \underline{q_1}, \underline{q_2}\right)$ *and* $\left(\overline{t}, \overline{q_1}, \overline{q_2}\right)$ *under full regulation. Notice that* $TS\left(\underline{t}, \underline{q_1}, \underline{q_2}, \overline{t}, \overline{q_1}, \overline{q_2}\right)$ *under full regulation is equal to* $TS\left(\underline{t}, \overline{t}\right)$ *under light handed regulation. We know that*

$$\pi_1\left(\underline{t}, \underline{c_1}, c_2\right) \geqslant 0$$

By construction,

$$\pi_1\left(\underline{t}, \underline{c_1}, c_2\right) = \left(a - b\underline{q_1} - b\underline{q_2} - c_0 - \underline{c_1}\right)\underline{q_1} + \left(\underline{t} - c_0\right)\underline{q_2} \geqslant 0$$

Hence the individual rationality constraint for the type $\underline{c_1}$ *incumbent is satisfied under full regulation. Similarly, individual rationality is satisfied for the type* $\overline{c_1}$ *incumbent and for the entrant. Note that under Cournot competition in the downstream market, the entrant will have strictly positive profits if it produces a positive quantity, as price will exceed its marginal and average cost. Now consider the incentive compatibility constraint for the type* $\underline{c_1}$ *incumbent:*

$$\pi_1\left(\underline{t}, \underline{c_1}, c_2\right) \geqslant \pi_1\left(\overline{t}, \underline{c_1}, c_2\right)$$

By construction of $(\overline{q_1}, \overline{q_2})$*, it must be true that*

$$\pi_1\left(\overline{t}, \underline{c_1}, c_2\right) > \left(a - b\overline{q_1} - b\overline{q_2} - c_0 - \underline{c_1}\right)\overline{q_1} + \left(\overline{t} - c_0\right)\overline{q_2}$$

because $(\overline{q_1}, \overline{q_2})$ *is the outcome of profit maximizing behavior in the downstream market for the type* $\overline{c_1}$ *incumbent, and not for the type* $\underline{c_1}$ *incumbent, and* $\underline{c_1} < \overline{c_1}$*. Hence, incentive compatibility for the type* $\underline{c_1}$ *incumbent will not bind under the fully regulated scheme. Similarly, incentive compatibility for the type* $\overline{c_1}$ *incumbent will not bind. Therefore, starting from the same level of expected total surplus achieved by the light handed contract* $\left(\underline{t}, \overline{t}\right)$*, the regulator can increase expected total surplus by increasing the quantity produced by the incumbent firm without violating any individual rationality or incentive compatibility constraints.* ■

It is important to notice that this argument cannot deliver a proof that full regulation dominates light handed regulation in the social sense, when there is uncertainty about the type of the entrant, and no (non-trivial) menu of contracts can be offered to the entrant. To understand why this is the case, consider following the same line of proof with uncertainty about the type of entrant. Profits for a particular type of the incumbent, say the low cost type, will be given by

$$\beta\left(\pi_1\left(\underline{t}, \underline{c_1}, \underline{c_2}\right)\right) + (1-\beta)\,\pi_1\left(\underline{t}, \underline{c_1}, \overline{c_2}\right)$$

In order to offer under full regulation a contract that replicates the expected profit of this type, the regulator must offer $\left(\underline{t}, \underline{q_1}, \underline{q_2}\right)$ such that

$$\pi_1\left(\underline{t}, \underline{q_1}, \underline{q_2}\right) = \beta\left(\pi_1\left(\underline{t}, \underline{c_1}, \underline{c_2}\right)\right) + (1-\beta)\,\pi_1\left(\underline{t}, \underline{c_1}, \overline{c_2}\right)$$

However, it may be that

$$TS\left(\underline{t}, \underline{q_1}, \underline{q_2}\right) \neq \beta\left(TS\left(\underline{t}, \underline{c_1}, \underline{c_2}\right)\right) + (1-\beta)\, TS\left(\underline{t}, \underline{c_1}, \overline{c_2}\right)$$

Hence a contract can be constructed under full regulation so that each type of incumbent has exactly the same level of profits by choosing the contract designed for its type, as it achieves under the light handed regime. However, that contract may not provide the same level of total surplus from the market.[7], and may provide strictly less total surplus than its light handed counterpart. The regulator can still improve on this social surplus under full regulation, by the argument used above. However, if the initial point under full regulation has strictly lower social surplus, it will not be true in general that the optimal contract under full regulation will dominate the optimal contract under light handed regulation.

Note that were the regulator allowed to use discretion in the exercise of full regulation instruments, she would always be able to improve social welfare by moving to full regulation. For example, the regulator could offer under full regulation two possible access prices, but for each access price chosen it could provide a menu or range of quantities that could be produced. In such a situation, the regulator could easily replicate any result of optimal light handed regulation with a fully regulated menu of contracts that provided the same levels of profits to firms as well as the same level of net consumer surplus. It could then improve on this full regulated menu of contracts because incentive compatibility constraints would no longer bind under full regulation. Thus, a crucial assumption for our results is that the fully regulated regime allows but also imposes the use of more instruments.

3.3 Uncertainty about entrant's costs: Examples of full and light handed dominance

Here we provide three examples of full and light handed regulatory regimes, in which the use of more regulatory instruments may improve total surplus or reduce total surplus depending on parameters. This basic point can be shown in a model without an intermediate input or access problem. We consider situations with and without an intermediate good, and with or without perfect information about the incumbent's costs.

Example 1 *No intermediate input, homogenous products Cournot interaction, perfect information about incumbent's cost, incomplete information about potential entrant's cost. No regulation dominates quantity regulation.*

[7] The reason is simple. Both profit functions and net consumer surplus are convex in prices, but their degree of convexity may not be identical around the initial light handed regulation solution. Hence it is possible that the (t, q_1, q_2) under full regulation, for which the incumbent firm is indifferent between full and light handed regulation contracts, is associated to strictly lower total surplus.

Demand is given by $Q = 10 - P; Q = q_1 + q_2$.

Two firms, incumbent (1) and entrant (2).

No fixed costs for incumbent or entrant firm.

$c_1 = 4$.

$c_2 \in \{2, 6\}$, each occurring with probability $\frac{1}{2}$

Total surplus is defined as $TS = NCS + PS_1 + PS_2$.

$NCS = \frac{1}{2}Q^2; PS_1 = \pi_1; PS_2 = \pi_2$ since there are no fixed costs.

Under a no-regulation regime, two possible market outcomes occur with equal probability:

Outcome 1: $q_1 = \frac{8}{3}; q_2 = \frac{2}{3}; P = \frac{20}{3}; TS \simeq 13.111$.

Outcome 2: $q_1 = \frac{4}{3}; q_2 = \frac{10}{3}; P = \frac{16}{3}; TS \simeq 23.778$.

Thus expected total surplus $E(TS) \simeq 18.444$.

Compare this with the best outcome under full regulation, i.e. setting quantities for both firms. Note that the regulator cannot set a menu of contracts, as the incumbent firm, whose cost is known, would choose the contract that offers it higher profits. The entrant firm by assumption cannot contract with the regulator, hence it cannot choose from a menu of regulated quantities. Hence the regulator's problem is

$$\underset{q_1^R, q_2^R}{Max} \left(10 - q_1^R - q_2^R - 4\right) q_1^R + \frac{1}{2}\left(10 - q_1^R - q_2^R - 6\right) q_2^R + \frac{1}{2}\left(10 - q_1^R - q_2^R - 2\right) q_2^R + \frac{\left(q_1^R + q_2^R\right)^2}{2}$$

subject to

$$\left(10 - q_1^R - q_2^R - 4\right) q_1^R \geq 0$$
$$\left(10 - q_1^R - q_2^R - 6\right) q_2^R \geq 0$$
$$\left(10 - q_1^R - q_2^R - 2\right) q_2^R \geq 0$$

The constraints imply that for $q_1^R > 0$, the regulator must provide $q_1^R + q_2^R \leq 6 \iff P \geq 4$. Also, for $q_2^R > 0$, the regulator must provide $q_1^R + q_2^R \leq 4 \iff P \geq 6$. We are assuming that the regulator cannot set $q_2^R > 0$ and then allow the entrant firm to choose between this value of q_2^R and $q_2^R = 0$. In other words, if the regulator sets a positive quantity for the entrant, that means it must guarantee that entry will occur, otherwise it must set zero quantity for the entrant.

Under these conditions, the regulator will choose $q_1^R = 6, q_2^R = 0$. The entrant has zero profits, the incumbent has zero profits, and $NCS = 18$. Hence, $TS = 18 < 18.444$ found above. Given the limitations (inflexibility) in the use of quantity regulation as an instrument, surplus from this market is higher without any regulation

Example 2 *No intermediate good, homogenous products Cournot interaction, asymmetric information about incumbent's cost, incomplete information about potential entrant's cost. Under slightly different parameter settings, no regulation or quantity regulation can dominate.*

Again demand is given by $Q = 10 - P; Q = q_1 + q_2$.

The two firms' costs are given by:

$c_1 \in \{3, 5\}$, each occurring with probability $\frac{1}{2}$

$c_2 \in \{1, 5\}$, each occurring with probability $\frac{1}{2}$

Now under a no regulation regime, there will be four possible market outcomes, each occurring with probability $\frac{1}{4}$. The outcomes will be:

$c_1 = c_2 = 5 \Longrightarrow q_1 = \frac{5}{3}; q_2 = \frac{5}{3}; P = \frac{20}{3}; TS = 11.111.$

$c_1 = 5; c_2 = 1 \Longrightarrow q_1 = \frac{1}{3}; q_2 = \frac{26}{6}; P = \frac{32}{6}; TS = 29.778.$

$c_1 = 3; c_2 = 5 \Longrightarrow q_1 = 3; q_2 = 1; P = 6; TS = 18.$

$c_1 = 3; c_2 = 1 \Longrightarrow q_1 = \frac{5}{3}; q_2 = \frac{22}{6}; P = \frac{28}{6}; TS = 30.444.$

Expected total surplus is then 22.333.

Under full regulation, contracts $\left(\underline{q_1}, \underline{q_2}, \overline{q_1}, \overline{q_2}\right)$ will be offered in order to maximize expected total surplus subject to the constraints:

Individual rationality for incumbent types

$$\left(7 - \underline{q_1} - \underline{q_2}\right) \underline{q_1} \geqslant 0; \left(5 - \overline{q_1} - \overline{q_2}\right) \overline{q_1} \geqslant 0$$

Incentive compatibility for incumbent types

$$\left(7 - \underline{q_1} - \underline{q_2}\right) \underline{q_1} \geqslant \left(7 - \overline{q_1} - \overline{q_2}\right) \overline{q_1}; \left(5 - \overline{q_1} - \overline{q_2}\right) \overline{q_1} \geqslant \left(5 - \underline{q_1} - \underline{q_2}\right) \underline{q_1}$$

Individual rationality for entrant types

$$\left(9 - \underline{q_1} - \underline{q_2}\right) \underline{q_2} \geqslant 0; \left(5 - \underline{q_1} - \underline{q_2}\right) \underline{q_2} \geqslant 0; \left(9 - \overline{q_1} - \overline{q_2}\right) \overline{q_2} \geqslant 0; \left(5 - \overline{q_1} - \overline{q_2}\right) \overline{q_2} \geqslant 0$$

The resulting contracts are

$$\underline{q_1} = 7; \underline{q_2} = 0; \overline{q_1} = 0; \overline{q_2} = 5$$

And resulting social surplus is 23.5, which dominates the result under no regulation. Notice that uncertainty about the incumbent's cost parameter allows the regulator here to use a menu with two sets of quantities, and the added flexibility in this particular case makes quantity regulation more attractive than no regulation. Put another way, the use of more instruments becomes relatively more attractive as asymmetric information with regard to the incumbent firm increases.

Now consider the same example, changing the entrant's cost level to $c_2 \in \{1, 6\}$, again each occurring with probability $\frac{1}{2}$. With no regulation, expected total surplus falls to 21.9167. Under full regulation, the constrained optimal contracts will now be

$$\underline{q_1} = 7; \underline{q_2} = 0; \overline{q_1} = 0; \overline{q_2} = 4$$

and the associated expected total surplus is 21.25, so that now the no regulation policy dominates quantity regulation. For some intuition on why the regulator cannot improve on these contracts, consider the contract designed for the high cost incumbent type. Given that this type of incumbent does not produce, the regulator cannot set the entrant's quantity above 4, because the high cost entrant would have negative profits in that case. The regulator could increase the total quantity in the market by setting the entrant's quantity to zero and the incumbent's at 5. This would improve total surplus from the contract designed for the high cost incumbent. However, such a move would cause incentive compatibility for the low cost incumbent to be violated, because this type will now prefer the high cost contract. To maintain incentive compatibility, the regulator would then have to offer a pooling contract with no production by the entrant and 5 units produced by either type of incumbent. Expected total surplus would decrease to 17.5.

Example 3 *Intermediate good, homogenous products Cournot interaction, perfect information about incumbent's cost, incomplete information about potential entrant's cost. Light handed regulation dominates full regulation*

Once more demand is given by $Q = 10 - P; Q = q_1 + q_2$.

The two firms' costs are given by:

$c_0 = 2; c_1 = 4.$

$c_2 \in \{1, 5\}$, each occurring with probability $\frac{1}{2}$.

Under light handed regulation, the quantities produced are given by 7 and 8 above. Unconstrained maximization of total surplus results in a negative access price ($t = -7$), which clearly violates both individual rationality and non-negative production constraints. The constrained optimal access price is the access price that makes the individual rationality constraint for the high cost incumbent bind. The constraint can be written as

$$\left(\frac{a-1}{3}\right)^2 + (a-2)\left(\frac{14-2a}{3}\right) \geqslant 0$$

hence $t = 1.9689$ and resulting expected total surplus is 11.975.

Under full regulation, the regulator will offer (t, q_1, q_2) to maximize total surplus while satisfying one individual rationality constraint for the known type of incumbent, and one individual rationality constraint for each type of entrant. The constraints are then:

$(4 - q_1 - q_2)\, q_1 + (t - 2)\, q_2 \geqslant 0$

$(5 - q_1 - q_2 - t)\, q_2 \geqslant 0$

$(9 - q_1 - q_2 - t)\, q_2 \geqslant 0$

The regulator here can not do better than offering the contract $(t, q_1, q_2) = (2, 0, 3)$, which yields expected total surplus of 10.5, less than the expected total surplus under light handed regulation. Consider other possible contracts: the regulator could set entrant's quantity to zero, access price would become irrelevant, and the incumbent could produce as much as 4, an outcome that yields strictly lower total surplus. To have both firms producing the regulator could offer $(t, q_1, q_2) = (1.75, 1.5, 1.75)$, but this would yield expected total surplus of $9.625 < 10.5$. We conclude that light handed regulation provides higher expected total surplus in this case. Our conjecture at this point is that adding the intermediate good and access price to the regulator's problem makes abandoning the quantity setting instruments relatively more attractive, because the regulator is still left with a tool that influences market outcomes. However, we cannot yet show this as a general result.

4 Conclusions

In this paper we have considered a model of light handed regulation, in which regulatory instruments available are reduced to the price at which a vertically integrated incumbent firm grants entrants access to an essential input. We find that in this model the socially optimal access price generally provides a subsidy to entrant firms, and favors entrants more as they are more efficient with respect to the incumbent firm.

We then compare expected total surplus, defined as the unweighted sum of net consumer surplus and producer surplus, under light handed and fully regulated regimes. We find that with perfect information about cost characteristics of potential entrants, a larger number of regulatory instruments is always welfare-improving. However, when the regulator has incomplete information about entrant costs, and cannot remedy this complete information by providing the entrant with a menu of regulatory contracts, then light handed regulation can dominate full regulation from the social perspective.

This result indicates some motivation for the reduction of regulatory instruments, that is, a greater reliance on competition to increase total market surplus. In particular, when regulatory schemes with many instruments are rigid because of legislative or judicial constraints on regulatory discretion, it may be socially preferable to reduce the number of instruments included in these schemes.

The results here must be generalized, so that a generic characterization of situations in which one regulatory regime or the other dominates can be made. Clearly the situations in which one or the other regime dominates would change if we were to assume differentiated products, price rather than quantity competition in the downstream market, or a larger number of firms. Finally, our result depends on an assumption about the rigidity (incompleteness) of regulatory contracts; an important goal would be to discover what extent of rigidity is necessary in order for light handed regulatory schemes to be socially preferable.

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