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Efficient access pricing and endogenous market structure

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Abstract

We analyse a (differentiated good) industry where an incumbent firm owns a network good (essential input) and faces potential competition in the (downstream) retail market. Unlike the traditional approach, we consider a scenario where the decision to compete or not in the downstream segment is endogenous, and this decision depends on the particular mechanism designed by the utilitarian regulator. We assume that the technology of the potential entrant is private information. We derive the efficient (Ramsey) prices and access charge taking the impact of a non-discriminatory mechanism on entry decision into account. We assert that the optimal pricing formula must include a Ramsey term that is inversely related to the "modified" superelasticity of the retail good under consideration. We further show, under unknown cost, that there might be "excess" or "too little" entry compared to the socially optimal level.

Keywords: non-discriminatory access, endogenous competition, modified superelasticity

JEL classification: L11, L51, D82

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1 Introduction

This paper concentrates on regulated industries where the supply of final goods and services to consumers requires the use of an essential input. An essential input may be a facility or an infrastructure. It is used to enable competing firms to serve their final customers and cannot be cheaply duplicated. Often essential facility constitutes a bottleneck in the production chain. Examples of such bottleneck inputs are local loop (telecommunications), transmission grid (electricity), pipelines (gas), tracks and stations (rail transportation) and local delivery network (postal services).[1] The owner of such an input has incentives to use its dominant position to monopolize the complementary segments of the market. Therefore, to introduce competition in some market segments of these industries, for examples for long distance calls, electricity generation, gas extraction, rail and freight services or the production of presorted mail, the competitors should be granted access to the essential facility. Regulation of both the access conditions and the access price is then of prime importance in these industries.

The economics of efficient access pricing (Laffont and Tirole 1994, Laffont and Tirole 2000, Armstrong, Doyle and Vickers, 1996) aim at deriving pricing schemes that maximize the total welfare and that guarantee that firms break even. This last point means in particular that the owner of the essential input manages to cover all its cost with both the access receipts and its downstream profit. The efficient access pricing approach prescribes that, for each retail product, the associated Lerner index is inversely related to the *superelasticity* of the product. This form of pricing is often referred to as Ramsey pricing.

In this traditional approach, it is assumed that the regulator knows for all the market segments which firms will operate. Consequently, Ramsey prices do not take into account the impact of prices on the decision of firms to enter or not a particular segment of the market. However, since the access price determines the overall profitability of firms' downstream operations, it must have an impact on the entry decision of firms in those situations where the market structure is not taken as given.

In this paper we analyze the impacts of access prices on the entry decision of a firm in the market. We derive Ramsey prices when the regulator is unaware of the operating cost of a potential competitor of the incumbent firm (which is the owner of the essential facility). In our model, the regulator sets flat retail prices and access charge in order to maximize social welfare. Consequently, the competitor's decision of whether to enter the market or not depends on the regulatory mechanism. A low access charge implies that a firm is more likely to enter. The Ramsey prices corresponding to this situation are such that the associated Lerner index for each retail product is inversely related to its *modified superelasticity*. These modified superelasticities take into account the uncertainty over the entry decision. For the products marketed by the entrant, there is an additional

[1] See Laffont and Tirole (2000, chapter 3).

entry correction term in the Lerner index. Obviously, if entry always occurs, there is no uncertainty over entry and our problem is equivalent to the traditional approach.

The main objective of this paper is to show how Ramsey prices should be adapted when the market structure is not taken as given. To derive these optimal pricing schemes, we make the following assumptions. First, we assume that the regulator has the power to set the retail and access prices. This implies that the incumbent is totally passive: it takes prices as given and supplies the quantities that exhaust the demand for its product at these prices. The entrant is also passive with respect to its supply decision but it is active with respect to its entry decision. The firm enters the market only if it can realize a non-negative profit. If the demand for its product is positive, entry occurs if the entrant realizes a non negative margin on its sales. Clearly, this depends both on its private cost and on the regulated prices and access charge. Second, we assume that the regulator cannot extract the entrant's private information on its cost by using a menu of prices and access charges. Hence, we consider a uniform pricing scheme that applies indifferently to all types of the entrant. This is a source of inefficiency but it can be justified by the non-discriminatory rule that a regulator often uses in designing access prices.[2] What are the exact implications of the non-discriminatory access requirement is beyond the objective of this paper. The readers interested in this topic can consult the discussion in Laffont and Tirole (2000, chapter 3), and Pittman (2004). Offering different self-selecting pricing schemes is not *per se* a discriminatory practice since all firms have access to the same pricing schemes. However, the German competitive authority (the Bundeskartellampt) urged the owner of the rail infrastructure DB Netz to remove its TPS98 tariff for access because it was considered as discriminatory. The TPS98 consisted of two different pricing schemes: a two-part tariff for larger carriers and a per-unit access charge for smaller carriers (see Pittman, 2004). We leave aside this discussion and derive Ramsey prices when the regulator is bound to use flat prices and access charge.

The current model bears resemblance with few other earlier works in the literature on access pricing. Lewis and Shappington (1999) consider mechanisms under price competition and asymmetric information where the entry decision is taken as given. Gautier and Mitra (2003) consider an environment where the firms produce homogenous products and compete sequentially in quantities. In their model, the market structure is endogenous and they show that inefficient entry can occur, i.e., a more cost effective firm could not enter the market or a less cost effective firm may enter the market. As an alternative to Ramsey pricing, the efficient component pricing rule (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

[2] In the ongoing liberalization process in Europe, the European directives on telecommunication (90/388/EEC), electricity (96/92/EC), gas (2003/55/EC), rail (2002/14/EC) and postal services (96/67/EC) impose that the essential facility owner grants access to competitors on the basis of a *transparent and non-discriminatory* tariff.

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, 2000, Armstrong, Doyle and Vickers, 1996).

2 The Model

We consider an industry where two firms potentially operate in the downstream segments of the market. The incumbent operator (I) produces two goods: a final good in quantity x_I and a network good. The potential entrant (E) produces a final good in quantity x_E. The two products are differentiated according to some quality parameters. Each firm uses a unit of the network as an (essential) input to produce one unit of its final good. There are two types of cost associated with this network input: a fixed cost k_0 and a constant marginal cost c_0. The product of firm j involves a constant marginal c_j for $j = I,\, E$. The entrant pays a per unit price (the access charge) α for the use of the network.

The incumbent firm is either a duopolist (regime d) or a monopolist (regime m) in the retail market depending upon whether E operates there or not. The demand for the final goods/services at prices $(p_I,\, p_E)$ faced by I is given by:

$$x_I = \begin{cases} x_I^d(p_I,\, p_E), & \text{if } E \text{ enters,} \\ x_I^m(p_I,\, p_E), & \text{if } E \text{ does not enter.} \end{cases}$$

The monopolist's demand depends on p_E due to a possible existence of limit price. The demand faced by E is $x_E = x_E^d(p_I,\, p_E)$. Let η_j and η_{jk} be the own and cross price elasticities of x_j^d (for $j,\, k = I,\, E$), respectively, and let ϵ_I be the own price elasticity of x_I^m. For a given p_I, we have $x_I^m(p_I,\, .) \geq x_I^d(p_I,\, p_E)$. A fraction of the consumers that wishes to buy the product of E at price p_E purchases from I at price p_I when the entrant stays out of the market. The gross consumer surplus from the downstream products is given by $U(x_I,\, x_E)$, where U is the indirect utility function. We assume that if firm j is inactive, there are values of x_j such that $U(x_j = 0,\, x_k) > 0$, for $j,\, k = I,\, E$.

The cost parameters $(k_0,\, c_0,\, c_I)$ of the incumbent firm are common knowledge. The total costs that I incurs when it produces x_I and its rival produces x_E are given by $k_0 + c_0(x_I + x_E) + c_I x_I$. Entrant's marginal cost c_E is private information, and is distributed according to a probability distribution function $G(c_E)$ on the interval $[\underline{c},\, \bar{c}]$. Let $g(c_E)$ be the continuous and differentiable density function associated with $G(c_E)$. The probability distribution of c_E is common knowledge and we assume that $g(c_E) > 0$ for all c_E.

We consider a fully regulated market where a utilitarian regulator sets the retail prices p_I and p_E and the access charge α in order to maximise social welfare. We adopt the account convention that the regulator receives the sales revenue of the incumbent and makes monetary transfers to reimburse the costs of network. If E enters the market it pays the incumbent αx_E for the use of the network good. Since the net utility of the incumbent firm must be non-negative, the welfare maximisation problem induces prices that are similar to Ramsey prices. In this environment, the only decision the potential entrant takes is whether or not to supply the quantities $x_E(p_I, p_E)$ in the downstream market.

Regulating retails prices in addition to the access conditions, is particularly important when the firms are not competitive. Consider an entrant who possesses market power. The regulator needs at least two instruments, namely, the retail prices (to regulate its supply) and the access charge (to regulate its contribution to the network financing), with both instruments having an impact on the entry decision.[3] Had the entrant belonged to a competitive fringe, only one regulatory instrument (say, the access charge) would have been sufficient.

Laffont and Tirole (2000) analyze the case where the firms are competitive. In their framework, the firms realise zero profit, and the regulator fixes only the access price. Under symmetric information, the problem is similar to the above case where the regulator fixes the retail and the access prices. This is no longer true under asymmetric information. With competitive firms, E sets its price equal to its marginal cost: $p_E = c_E + \alpha$, and it enters the market if $x_E^d(p_I, p_E = c_E + \alpha) > 0$, i.e., entry occurs if there is a positive demand for the product of E. If the regulator sets retail and and access prices, entry occurs if the entrant realises a non-negative profit, i.e., if $x_E > 0$ and $(p_E - c_E - \alpha) \geq 0$.

[Insert Figure 1 here]

The timing of the event, which is summarised in Figure 1, is as follows. The entrant learns its cost c_E privately. Then the regulator sets p_I, p_E and α. After being offered the mechanism (p_I, p_E, α), E decides on entry. If E decided to enter the market, each firm j supplies in quantity $x_j^d(p_I, p_E)$ for $j = I, E$. Otherwise, I supplies in quantity $x_I^m(p_I, .)$.

In the following sections we derive the Ramsey prices and the efficient access charge both under symmetric (when E's cost is known to the regulator) and asymmetric information.

3 Pricing under Symmetric Information

In this section we assume that c_E is publicly known. First we consider the case of a duopoly market. The utilitarian regulator maximises social welfare by setting the retail

[3] Alternatively, the regulator can use a two-part tariff, where the variable part aims at regulating its supply and the fixed part aims at regulating its contribution to the network financing. Gautier and Mitra (2003), Lewis and Sappington (1996) use a two-part tariff to regulate the behavior of a non-competitive entrant.

prices $(p_I,\, p_E)$ and the access charge α. We have mentioned earlier that, without any loss of generality, we assume that the regulator reimburses costs, receives the sales revenue of the downstream product of the incumbent, and that the entrant pays the access charge $\alpha\, x_E$ directly to the incumbent firm. The regulator makes a transfer t to the incumbent for the provision of the network good. The utility level of the incumbent firm is then $t + \alpha\, x_E$. The profit of the entrant is given by $(p_E - c_E - \alpha)x_E^d$. Public funds, which are raised by distortionary taxes, have the shadow price $1 + \lambda$ (where $\lambda > 0$). Total funds to be raised are given by:

$$t + \left[c_0(x_I^d + x_E^d) + k_0\right] - (p_I - c_I)x_I^d \,.$$

The consumers' utility is given by:

$$V^d \equiv U(x_I^d,\, x_E^d) - p_I x_I^d - p_E x_E^d - (1+\lambda)\left(t + c_0(x_I^d + x_E^d) + k_0 - (p_I - c_I)x_I^d\right), \quad (CS^d)$$

where $U(x_I^d,\, x_E^d)$ is the gross surplus from consuming the downstream products, which is assumed to be concave. Hence, the regulator sets p_I, p_E and α in order to maximise the following social welfare:

$$\begin{aligned} W^d \equiv U(x_I^d,\, x_E^d) &- \left[c_0(x_I^d + x_E^d) + k_0 + c_I)x_I^d + c_E)x_E^d\right] \\ &-\lambda\left[t + c_0(x_I^d + x_E^d) + k_0 - (p_I - c_I)x_I^d\right], \end{aligned}$$

subject to the participation constraints of the firms:

$$t + \alpha\, x_E^d \geq 0, \qquad (PC_I)$$

$$(p_E - c_E - \alpha)x_E^d \geq 0. \qquad (PC_E)$$

Since public funds are costly, the participation constraint of the incumbent binds at the optimum. Also, the access price α is set such a way in order that E earns zero profit. Taking these facts into account the objective function of the regulator reduces to:

$$U(x_I^d,\, x_E^d) - (1+\lambda)\left[k_0 + (c_0 + c_I)x_I^d + (c_0 + c_E)x_E^d\right] + \lambda(p_I x_I^d + p_E x_E^d).$$

The solutions to the above maximisation problem can be summarised as follows.

$$L_j \equiv \frac{p_j - c_0 - c_j}{p_j} = \frac{\lambda}{1+\lambda}\,\frac{1}{\hat{\eta}_j}, \ \text{ for } \ j = I,\, E, \qquad (1)$$

where

$$\hat{\eta}_j \equiv \frac{\eta_j(\eta_j\eta_k - \eta_{jk}\eta_{kj})}{\eta_j\eta_k + \eta_j\eta_{jk}}, \ \text{ for } \ j,\, k = I,\, E.$$

The above expression $\hat{\eta}_j$ is the superelasticity of good $j = I,\, E$, which takes into account the fact that the two firms sell differentiated products in the retail market. Under the assumption of substitutability ($\eta_{jk} > 0$ for $j,\, k = I,\, E$) we have $\hat{\eta}_j < \eta_j$. Further, the Lerner index L_j of firm j is inversely related to its superelasticity.

Next, consider the case of a monopoly market, i.e., the incumbent faces no rival in the downstream segment of the market. In this case the total funds to be raised are given by:

$$t + c_0 x_I^m + k_0 - (p_I x_I^m - c_I x_I^m)\,.$$

Hence, the net consumers' surplus is given by:

$$V^m \equiv U(x_I^m,\, 0) - p_I x_I^m - (1+\lambda)(t + c_0 x_I^m + k_0 + c_I x_I^m - p_I x_I^m), \tag{CS^m}$$

The utilitarian regulator designs the mechanism $(p_I,\, p_E,\, \alpha)$ to solve the following social welfare:

$$W^m \equiv V^m + t,$$

subject to $t \geq 0$.

Again the net transfer t must be equal to zero for the participation constraint of the incumbent to be binding. Hence the regulator's objective function reduces to:

$$U(x_I^m,\, 0) + \lambda p_I x_I^m - (1+\lambda)(c_0 + c_I) x_I^m - (1+\lambda) k_0\,,$$

The solution to the above maximisation problem can be summarised as follows.

$$L_I \equiv \frac{p_I - c_0 - c_I}{p_I} = \frac{\lambda}{1+\lambda}\,\frac{1}{\epsilon_I}. \tag{2}$$

In this case the Lerner index of the monopolist is inversely related to the own price elasticity of x_I^m.

Now we would like to see if, under symmetric information, entry is socially efficient. In other words, we would look for a cut-off level of marginal cost of E such that if c_E is different from this cut-off level, maximum social welfare associated to duopoly is different from that in the case of monopoly. This is summarised in the following proposition.

PROPOSITION **1** *There exists a level of marginal cost c^* of E below which entry is always socially optimal.*

PROOF Let $W^{SI,d}(c_E)$ and $W^{SI,m}$ be the maximum value functions of the above two maximisation problems, respectively. Notice that $W^{SI,m}$ is independent of c_E. Now by Envelope theorem,

$$\frac{d\,W^{SI,d}(c_E)}{d\,c_E} = -\,(1+\lambda)\,x_E^d$$

Given that $\lambda \geq 0$ and $x_E^d > 0$, the above expression is strictly negative, i.e., $W^{SI,d}(c_E)$ is strictly decreasing in c_E. Now define c^* such that $W^{SI,d}(c^*) = W^{SI,m}$. Also, since the function is strictly decreasing, we must have $W^{SI,d}(\underline{c}) > W^{SI,d}(\bar{c})$. Such c^* exists under the assumption that $W^{SI,d}(\underline{c}) \geq W^{SI,m} \geq W^{SI,d}(\bar{c})$.[4] $\square$

In the next section we analyse the efficient pricing under asymmetric information, i.e., when the marginal cost of the entrant is not known to the regulator.

4 Pricing under Asymmetric Information

In this section we assume that E learns its marginal cost privately before the regulator designs the mechanism (p_I, p_E, α), although the $G(c_E)$, the distribution of entrant's marginal cost is common knowledge. In this case the regulator maximises the sum of the social welfare under each kind of market structure, namely duopoly and monopoly. Notice that, after observing the regulatory mechanism, E makes the decision on entry. It enters if $\Pi_E^d \equiv (p_E - c_E - \alpha)x_E^d \geq 0$. Define $\hat{c}$ such that $p_E - \hat{c} - \alpha = 0$. Given that $x_E^d(p_I, p_E) > 0$, E enters only if $c_E \leq \hat{c}$. Thus, given the mechanism, $\hat{c}$, and hence the market structure (duopoly or monopoly) are endogenous. Notice that with probability $G(\hat{c})$ the market structure is a duopoly, and the incumbent is a monopolist with the complementary probability. Under the assumption of unknown marginal cost, the regulator then solves the following maximisation problem:

$$\max_{\{p_I, p_E, \alpha\}} \int_{\underline{c}}^{\hat{c}} W^d \, dG(c_E) + \int_{\hat{c}}^{\bar{c}} W^m \, dG(c_E),$$

subject to

$$G(\hat{c})(t + \alpha\, x_E^d) + (1 - G(\hat{c}))t \geq 0, \qquad (PC_I^{AI})$$

$$\alpha = p_E - \hat{c}, \qquad (PC_E^{AI})$$

The first constraint is the participation constraint of the incumbent, which implies that the expected utility of I must be non-negative. Because public funds are costly, this constraint binds at the optimum. The second constraint is the "zero-profit" condition of the type-$\hat{c}$ of E. As $\hat{c}$ is endogenous the superelasticities must be modified in order to take the impact of the mechanism on entry decision into account. Let us first define the "modified superelasticities" for the retail products. Let the average demands be $\bar{x}_I = G(\hat{c})\, x_I^d + (1 - G(\hat{c}))\, x_I^m$ and $\bar{x}_E = G(\hat{c})\, x_E^d$, respectively. Thus we can also define average elasticities as follows.

$$\bar{\eta}_j = -\frac{\partial \bar{x}_j}{\partial p_j}\frac{p_j}{\bar{x}_j}, \quad \text{for } j = I, E,$$

$$\bar{\eta}_{jk} = \frac{\partial \bar{x}_j}{\partial p_k}\frac{p_k}{\bar{x}_j}, \quad \text{for } j, k = I, E, \text{ and } j \neq k.$$

[4] We might have $W^{SI,m} > W^{SI,d}(\underline{c})$. In this case one may choose $c^* = \underline{c}$, and hence entry is never efficient. On the other hand, if $W^{SI,d}(\bar{c}) > W^{SI,m}$ we can choose $c^* = \bar{c}$, and hence entry is always efficient. But we concentrate on the most interesting case where $c^* \in (\underline{c}, \bar{c})$.

Now we define the following modified superelasticities:

$$\hat{\eta}_j^G = \frac{\bar{\eta}_j\left(\bar{\eta}_j\bar{\eta}_k - \bar{\eta}_{jk}\bar{\eta}_{kj}\right)}{\bar{\eta}_j\bar{\eta}_k + \bar{\eta}_j\bar{\eta}_{jk}}, \quad \text{for } j,\, k = I,\, E, \text{ and } j \neq k.$$

Notice that the above modified superelasticities are similar to that in case of symmetric information. Under unknown cost, the terms η_j and η_{jk} in $\hat{\eta}_j$ are replaced by $\bar{\eta}_j$ and $\bar{\eta}_{jk}$, respectively. The modified superelasticities depend on the entry decision of E (since it depends on $G(\hat{c})$, the number of cost types that enter the downstream market). In the following proposition we show that the modified superelasticity of a firm j can be expressed as a weighted sum of $\hat{\eta}_j$ and its value at $G(\hat{c}) = 0$.

Proposition **2** *The modified superelasticity of the product of each firm can be written in the following way.*

$$\begin{aligned} &(a) \qquad \hat{\eta}_I^G &=&\; q_I\,\hat{\eta}_I + (1-q_I)\,\epsilon_I, \\ &(b) \qquad \hat{\eta}_E^G &=&\; q_E\,\hat{\eta}_E + (1-q_E)\,r\,\eta_E, \end{aligned}$$

where

$$q_I \equiv \frac{G(\hat{c})(\eta_E + \eta_{IE})}{\bar{x}_I(\bar{\eta}_E + \bar{\eta}_{IE})}, \quad q_E \equiv \frac{G(\hat{c})(\eta_I + \eta_{EI})}{\bar{x}_I(\bar{\eta}_I + \bar{\eta}_{EI})} \quad \textit{and} \quad r \equiv \frac{\epsilon_I}{\epsilon_I + \eta_{EI}}.$$

Proof First, notice that $\bar{\eta}_I$ and $\bar{\eta}_{IE}$ can be expressed as follows.

$$\begin{aligned} \bar{\eta}_I &= \frac{G(.)x_I^d}{\bar{x}_I}\,\eta_I + \frac{(1-G(.))x_I^m}{\bar{x}_I}\,\epsilon_I, \\ \bar{\eta}_{IE} &= \frac{G(.)x_I^d}{\bar{x}_I}\,\eta_I. \end{aligned}$$

Also notice that $\bar{\eta}_E = \eta_E$ and $\bar{\eta}_{EI} = \eta_{EI}$. Substitute the above in the formulas of $\hat{\eta}_I^G$ and $\hat{\eta}_E^G$ to get the results. □

From the above proposition it is easy to see that $\hat{\eta}_j$ can be obtained by evaluating $\hat{\eta}_j^G$ at $\hat{c} = \bar{c}$, i.e., in the case where the optimal mechanism is such that all cost types of E can enter the retail market profitably. Also, since the products are substitutes ($\bar{\eta}_{jk} > 0$) we have $\hat{\eta}_j^G < \bar{\eta}_j$ for $j = I,\, E$. Also it is very easy to see that $\hat{\eta}_I^G$ is monotone in the probability of entry, G.[5] This fact is summarised in the following proposition and in Figure 2.

Proposition **3** *For $\epsilon_I > (<)\, \eta_I$, $\hat{\eta}_I^G$ is monotonically decreasing (increasing) in the probability of entry.*

[5]Similar conclusion can be drawn also for the entrant firm.

Proof It is easy to check that, given $\eta_{jk} > 0$, $\epsilon_I > (<)\, \eta_I$ is a necessary and sufficient condition for $\frac{\partial \hat{\eta}_I^G}{\partial G} < (>)\, 0$. □

[Insert Figure 2 about here]

In Figure 2 notice that $\hat{\eta}_I < \eta_I$ and $\hat{\eta}_I^G < \bar{\eta}_I$, since the goods are imperfect substitutes. Now we analyse the welfare maximisation problem when the marginal cost of E is unknown. In the following proposition we describe the pair (p_I, p_E) as part of the optimal mechanism. These prices are modified Ramsey prices which takes the endogeneity of the market structure into account. They are efficient in the sense that they maximise social welfare.

Proposition 4 *The optimal retail prices are given by:*

$$\begin{aligned} L_I &\equiv \frac{p_I - c_0 - c_I}{p_I} = \frac{\lambda}{1+\lambda} \frac{1}{\hat{\eta}_I^G}, \\ L_E &\equiv \frac{p_E - c_0 - c_E}{p_E} = \frac{\lambda}{1+\lambda} \frac{1}{\hat{\eta}_E^G} + Q(\hat{c}), \end{aligned}$$

where $Q(\hat{c}) \equiv \frac{1}{p_E(1+\lambda)} \left(\lambda(\hat{c} - c_E) - (\mathbf{E}[c_E | c_E \leq \hat{c}] - c_E)\right)$ *with* $\mathbf{E}$ *being the expectation operator.*

Proof See Appendix B. □

The Lerner index of the incumbent is similar to that derived in the symmetric information case. This is inversely proportional to the modified superelasticity of its product. When the marginal cost of E is private information, a similar regulatory mechanism fails to perfectly regulate entry. Hence, L_I depends on $G(\hat{c})$ through the modified superelasticity. We have already established that $\hat{\eta}_I^G$ can be expressed as an average of $\hat{\eta}_I$ and ϵ_I. This implies that for $G(.) = 1$ and $G(.) = 0$, we can obtain L_I equivalent to that in equations (1) and (2), respectively.

In case of E, its Lerner index is a sum of two terms. First, it involves a modified Ramsey term implying that L_E is inversely related to $\hat{\eta}_E^G$. Second, since the entry decision of the firm cannot be perfectly regulated, there is an additional "entry correction" term. This depends on the difference between $\hat{c}$ and the true realisation of c_E, and the difference between "expected type" that enters in equilibrium and the true realisation of c_E.

The optimal access charge α is determined from the remaining first order condition of the maximisation programme. Firm E decides to enter after observing the mechanism (p_I, p_E, α). All cost types of the entrant with marginal cost $c_E \leq \hat{c}$ enter since these types earn non-negative profits. Hence, the optimal mechanism influences $\hat{c}$, which is consequently determined endogenously from the condition: $\alpha = p_E + \hat{c}$. Using this, the optimal access charge can also be written as the following:

$$\frac{\alpha - c_0}{\alpha + \hat{c}} = \frac{\lambda}{1+\lambda} \frac{1}{\hat{\eta}_E^G} + Q(\hat{c})\,.$$

In the standard models of efficient access pricing as in Laffont and Tirole (2000), when the cost of the entrant is unknown to the regulator, this firm is offered a menu of contracts $(p_I(c_E), \, p_E(c_E), \, \alpha(c_E))$. Consequently, entry and hence the market structure are perfectly regulated. There is no entry decision per se made by E. In the above mentioned models the mechanism $(p_I(c_E), \, p_E(c_E), \, \alpha(c_E))$ is efficient in the sense that it maximises social welfare for a given market structure. On the other hand, the "efficient component pricing rule", which is based on contestable markets, is concerned with efficient entry. In the current model, we set up a model similar to Laffont and Tirole (1994) in order to derive welfare maximising retail and access prices that also take efficient entry decision into account. Our optimal mechanism gives rise to modified Ramsey prices.

5 Entry and Social Optimum

Now we analyse how does the entry decision, or equivalently $\hat{c}$, compare with the socially optimal entry level. In other words, we would like to see whether, under asymmetric information, there is inefficient entry compared to the social optimum. There are two possible forms of inefficiency: "excess entry" under asymmetric information if $\hat{c} > c^*$, and "too little entry" if $\hat{c} < c^*$.

In a related work, Gautier and Mitra (2003) find that (a) under asymmetric information entry is generically inefficient and (b) that both types of inefficiencies are possible. Thus, there is no systematic bias toward any particular form of inefficiency. In more specific contexts i.e., using specific assumptions on the distribution of the entrant's cost parameter, Gautier (2006) and Bloch and Gautier (2006) identify situations where one type of inefficient entry is not possible. Gautier (2006) observes that there is too little entry with both two-part and single tariffs for the access charge, the latter generating more entry. Bloch and Gautier (2006) study the choice between access and bypass as a function of the regulated access price. They identify a situation where, under asymmetric information, excessive bypass is possible, while excessive access does not emerge.

In our model, the cut-off entry point $\hat{c}$ is found by solving the first order condition of the maximisation problem in Section 4. As it clearly appears in this condition, the entry cut-off depends on the distribution of the entrant's cost parameter. Therefore, two different distributions are likely to generate two different cut-off points and entry is presumably not always efficient.

We can however identify a situation in which the cut-off entry point is identical under both symmetric and asymmetric information. As a matter of fact, if for all possible values of c_E, under symmetric information a duopoly is associated with a lower welfare level than a monopoly, there will be a total entry ban under symmetric information.

PROPOSITION **5** *If* $c^* \leq \underline{c}$*, then* $\hat{c} = \underline{c}$

Beyond that, we cannot identify a systematic bias in the entry decision. The following numerical examples illustrate this point. In order to see this we consider (inverse) demand functions for the retail goods of the following form:

$$p_j = 1 - x_j^d - \frac{x_k^d}{2}, \text{ for } j,\, k = I,\, E, \text{ and when there are two firms,}$$
$$p_I = 1.1 - x_I^m, \text{ when there is only the incumbent,}$$

With the above demand functions the gross consumer surplus under duopoly and monopoly are respectively given by:

$$\begin{aligned} U(x_I^d,\, x_E^d) &= (x_I^d + x_E^d) - \frac{1}{2}\left((x_I^d)^2 + (x_E^d)^2\right) - \frac{1}{2}\, x_I^d\, x_E^d, \\ U(x_I^m,\, 0) &= 1.1\, x_I^m - \frac{1}{2}\,(x_I^m)^2. \end{aligned}$$

We further assume that $\lambda = 0.2$, $c_0 = 0$, $c_I = 0.12$, and $k_0 = 0.01$. In what follows, we consider two examples (two different sets of values of the parameters) in order to compute c^* and $\hat{c}$. Under asymmetric information, if we consider that c_E is uniformly distributed on the interval $[\underline{c},\, \overline{c}]$ i.e., $g(c_E) = \frac{1}{\overline{c} - \underline{c}}$, different boundaries for this interval would generate different cut-off points inducing both types of inefficiencies.

EXAMPLE **1** The marginal cost of E, c_E is distributed uniformly over $[0.15,\, 0.20]$. In this case the efficient entry point under symmetric information is given by $c^* \simeq 0.18$. And the cut-off point under unknown marginal cost is given by $\hat{c} \simeq 0.17$. In this case there is "too little entry".

EXAMPLE **2** Now assume that c_E is distributed uniformly over $[0.15,\, 0.25]$. The efficient entry point under symmetric information is given by $c^* \simeq 0.18$. But the cut-off point under unknown marginal cost is given by $\hat{c} \simeq 0.22$. In this case there is "excess entry".

From the above two examples we see that there is no clear ranking between c^* and $\hat{c}$. The first example suggests that, under asymmetric information, there is insufficient entry compared to the social optimum. On the other hand, in the second example we find that there is excess entry into the downstream market compared to the socially optimum level.

6 Concluding Remarks

When the regulation of a potential entrant with unknown cost is under consideration, traditional Ramsey pricing formula does not take into account the impacts of regulatory mechanisms on the entry into the retail market. On the other hand, popular competition policies assert that access to essential inputs should be non-discriminatory (i.e., a common access fee for all types of users of the network facility). In this paper we show that a non-discriminatory mechanism has significant impact on the entry decision of the rival firm. We consider a regulatory environment where the retail prices and the access charge are set by a utilitarian regulator. The derivation of efficient access and retail prices must make use of a modified Ramsey pricing rule, which takes the impact of the mechanism on entry into account, instead of the traditional one. Hence, given the regulatory mechanism, the entry into the downstream market, and hence the market structure are endogenous. These depend crucially on the non-discriminatory regulatory mechanism in which the regulator cannot perfectly control the entry into the retail market.

In the current paper we first show that efficient retail and access prices under symmetric information coincide with the traditional Ramsey prices as derived in Laffont and Tirole (1994). Next, in the case where the entrant's cost is unknown, the efficient retail and access prices are modified Ramsey prices. In this regard we derive modified superelasticities of the retail goods which take the impact of the regulatory mechanism on the entry decision into account. Finally, we show that, under asymmetric information, there might occur "excess" or "too little" entry compared to the social optimum, i.e., there is no systematic bias towards any particular type of inefficient (due to private information) entry decision.

The above analyses are done under the assumption that the potential entrant posseses market power instead of being part of a competitive fringe. When the entrant is assumed to be competitive, one could draw conclusions that are similar to the ones found in the current paper. An interesting extension of the current model would be to consider a partially regulated industry where the regulator only designs the access fee (possibly a two-part tariff), and the firms compete in a Bertrand fashion in the downstream market.

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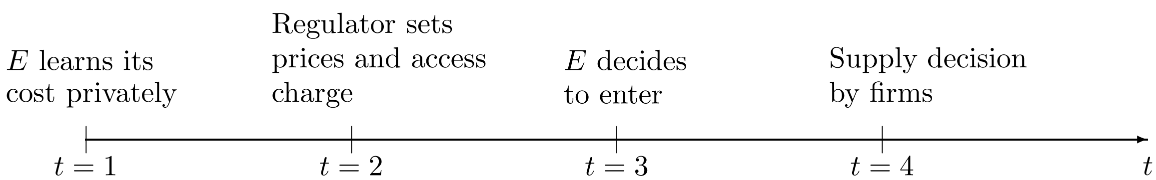

Figure 1: Timing of Events

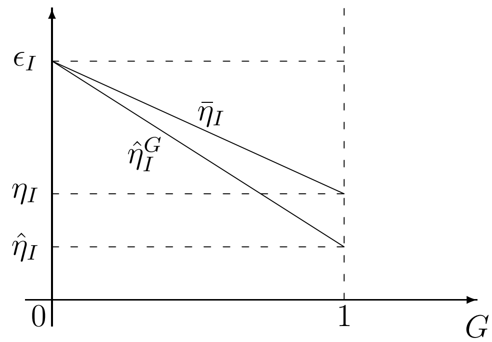

FIGURE 2. 1: MODIFIED SUPERELASTICITY OF x_I WHEN $\epsilon_I > \eta_I$

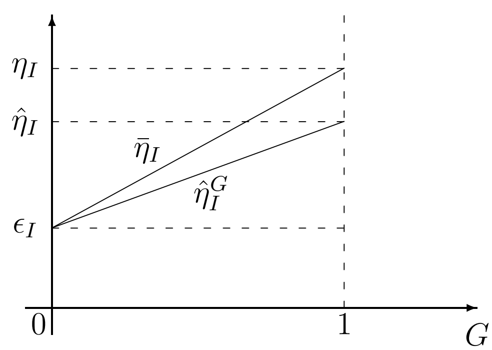

FIGURE 2. 2: MODIFIED SUPERELASTICITY OF x_I WHEN $\epsilon_I < \eta_I$

Appendix

A Pricing under Symmetric Information

When the marginal cost of the entrant is common knowledge, the regulator solves two separate maximisation problems in order to design the optimal mechanism (p_I, p_E, α): (a) when E enters the market, i.e., the retail market is a duopoly, and (b) when the incumbent is a monopolist. First we consider the case of a duopoly market, where the regulator maximises the following social welfare:

$$\begin{aligned} W^d \equiv\ & U(x_I^d, x_E^d) - p_I x_I^d - p_E x_E^d - \\ & (1+\lambda)\left[t + c_0(x_I^d + x_E^d) + k_0 - (p_I - c_I)x_I^d\right] + \\ & \left[t + \alpha\, x_E^d\right] + \left[(p_E - c_0 - c_E)x_E^d\right], \end{aligned}$$

subject to

$$t + \alpha\, x_E^d \geq 0, \tag{PC_I}$$

$$(p_E - c_E - \alpha)x_E^d \geq 0. \tag{PC_E}$$

It is easy to check that, at the optimum, both the constraints are satisfied with equality. If one incorporates these into the objective function, that reduces to:

$$U(x_I^d, x_E^d) + \lambda(p_I x_I^d + p_E x_E^d) - (1+\lambda)(c_0 + c_I)x_I^d - (1+\lambda)(c_0 + c_E)x_E^d - (1+\lambda)k_0\,.$$

The first order conditions with respect to p_I and p_E are given, respectively by:

$$(p_I - c_0 - c_I)\frac{\partial x_I^d}{\partial p_I} + (p_E - c_0 - c_E)\frac{\partial x_E^d}{\partial p_I} = -\frac{\lambda x_I^d}{1+\lambda}\,, \tag{3}$$

$$(p_I - c_0 - c_I)\frac{\partial x_I^d}{\partial p_E} + (p_E - c_0 - c_E)\frac{\partial x_E^d}{\partial p_E} = -\frac{\lambda x_E^d}{1+\lambda}\,. \tag{4}$$

Let us define by

$$\begin{aligned} &\eta_j \equiv -\frac{\partial x_j^d}{\partial p_j}\frac{p_j}{x_j^d} \quad \text{and} \quad \eta_{jk} \equiv -\frac{\partial x_j^d}{\partial p_k}\frac{p_k}{x_j^d} \quad \text{for} \quad j,\, k = I,\, E \quad \text{and} \quad j \neq k, \\ &L_j \equiv \frac{p_j - c_0 - c_j}{p_j} \quad \text{for} \quad j = I,\, E. \end{aligned}$$

Equations (3) and (4) can be rearranged to give

$$L_j = \frac{\lambda}{1+\lambda}\frac{1}{\hat{\eta}_j}\,, \ \text{ for } j = I,\, E,$$

where

$$\hat{\eta}_j \equiv \frac{\eta_j(\eta_j\eta_k - \eta_{jk}\eta_{kj})}{\eta_j\eta_k + \eta_j\eta_{jk}}, \text{ for } j,\, k = I,\, E.$$

The optimal access charge is given by:

$$\alpha = p_E - c_E.$$

Now consider the case when the incumbent is a monopolist in the retail market. The regulator then designs the mechanism $(p_I,\, p_E,\, \alpha)$ to maximise social welfare:

$$W^m \equiv U(x_I^m,\, 0) + \lambda p_I x_I^m - (1+\lambda)(c_0 + c_I)x_I^m - (1+\lambda)k_0 - \lambda t,$$

subject to $t \geq 0$.

The last inequality is the participation constraint of the incumbent, which binds at the optimum. Hence, the objective function of the regulator reduces to:

$$W^m \equiv U(x_I^m,\, 0) + \lambda p_I x_I^m - (1+\lambda)(c_0 + c_I)x_I^m - (1+\lambda)k_0\,.$$

The first order condition with respect to p_I is given by:

$$(p_I - c_0 - c_I)\frac{\partial x_I^m}{\partial p_I} = -\frac{\lambda x_I^m}{1+\lambda}\,. \tag{5}$$

Let us define by

$$\epsilon_I \equiv -\frac{\partial x_I^m}{\partial p_I}\frac{p_I}{x_I^m}\,.$$

Equation (5) can be rearranged to give

$$L_I = \frac{\lambda}{1+\lambda}\frac{1}{\epsilon_I}\,.$$

The above is the standard "inverse elasticity" rule of a monopoly firm. Notice that the Lerner indices of the firms are inversely related to the superelasticities in duopoly.

B Pricing under Asymmetric Information

When the marginal cost of the entrant is unknown to the regulator he designs a mechanism $(p_I,\, p_E,\, \alpha)$ in order to maximise the expected social welfare. Firm E decides to enter the market after observing the mechanism. We have already mentioned that all cost types of E that earn non-negative profits will enter the market. Define $\hat{c}$ such that $p_E - \hat{c} - \alpha = 0$. Hence, any type $c_E \leq \hat{c}$ will enter the market. Thus with probability

$G(\hat{c})$ the market structure is a duopoly, and the incumbent is a monopolist with the complementary probability. Hence, the social welfare in this case is given by:

$$
\begin{aligned}
\hat{W} &\equiv \int_{\underline{c}}^{\hat{c}} W^d \, dG(c_E) + \int_{\hat{c}}^{\bar{c}} W^m \, dG(c_E) \\
&= \int_{\underline{c}}^{\hat{c}} [U(x_I^d,\, x_E^d) - p_I x_I^d - p_E x_E^d - (1+\lambda)\left(t + c_0(x_I^d + x_E^d) + k_0 - (p_I - c_I)x_I^d\right) + \\
&\quad (t + \alpha\, x_E^d) + (p_E - c_E - \alpha)x_E^d] \, dG(c_E) + \\
&\quad \int_{\hat{c}}^{\bar{c}} [U(x_I^m,\, 0) - p_I x_I^m - (1+\lambda)(t + c_0 x_I^m + k_0 + c_I x_I^m - p_I x_I^m) + t] \, dG(c_E).
\end{aligned}
$$

When the market is a duopoly, the utility of I is $t + \alpha\, x_I^d$, and it is t in case of monopoly. The regulator designs the optimal mechanism that guarantees non-negative expected utility to I (the participation constraint of this firm). Hence, the utilitarian regulator solves the following maximisation problem:

$$\max_{\{p_I, p_E, \alpha\}} \hat{W},$$

subject to

$$
\begin{aligned}
&G(\hat{c})(t + \alpha\, x_E^d) + (1 - G(\hat{c}))t \geq 0, && (PC_I^{AI}) \\
&\alpha = p_E - \hat{c}, && (PC_E^{AI})
\end{aligned}
$$

Notice that for the regulator choosing α is equivalent to choosing $\hat{c} = p_E - \alpha$. Now define by

$$
\begin{aligned}
\hat{W}^d \equiv\ & U(x_I^d,\, x_E^d) + \lambda\, p_I\, x_I^d + \lambda\, p_E\, x_E^d - \\
& (1+\lambda)(c_0 + c_I)x_I^d - (1+\lambda)(c_0 + \hat{c})x_E^d - (1+\lambda)k_0\,,
\end{aligned}
$$

$$\text{and} \qquad H(\hat{c}) \equiv \int_{\underline{c}}^{\hat{c}} G(t)dt.$$

The participation constraint of the incumbent binds at the optimum. Incorporating both the constraints into the objective function, we can reduce the regulator's problem as follows:

$$\max_{\{p_I, p_E, \alpha\}} G(\hat{c})\hat{W}^d + (1 - G(\hat{c}))W^m + x_E H(\hat{c}).$$

Also define $\bar{x}_I \equiv G(.)x_I^d + (1 - G(.))x_I^m$ and $\bar{x}_E \equiv G(.)x_E^d$. The first order conditions with respect to p_I, p_E and $\hat{c}$ are given, respectively by:

$$(1+\lambda)\left[(p_I - c_0 - c_I)\frac{\partial \bar{x}_I}{\partial p_I} + (p_E - c_0 - \hat{c})\frac{\partial \bar{x}_E}{\partial p_I}\right] + \lambda \bar{x}_I + H(\hat{c})\frac{\partial x_E^d}{\partial p_I} = 0, \tag{6}$$

$$(1+\lambda)\left[(p_I - c_0 - c_I)G(\hat{c})\frac{\partial x_I^d}{\partial p_E} + (p_E - c_0 - \hat{c})\frac{\partial \bar{x}_E}{\partial p_E}\right] + \lambda \bar{x}_E + H(\hat{c})\frac{\partial x_E^d}{\partial p_E} = 0, \tag{7}$$

$$\left[\hat{W}^d - W^m\right] - \lambda\, x_E^d\, h(\hat{c}) = 0, \tag{8}$$

where $h(.)$ is the *hazard rate* associated to the distribution function $G(.)$, which is assumed to be monotonically increasing. Rearranging equations (6) and (7) we get

$$\begin{aligned} L_I &\equiv \frac{p_I - c_0 - c_I}{p_I} = \frac{\lambda}{1+\lambda}\frac{1}{\hat{\eta}_I^G}\,, \\ L_E &\equiv \frac{p_E - c_0 - c_E}{p_E} = \frac{\lambda}{1+\lambda}\frac{1}{\hat{\eta}_E^G} + Q(\hat{c})\,, \end{aligned}$$

where

$$\hat{\eta}_j^G = \frac{\bar{\eta}_j\left(\bar{\eta}_j\bar{\eta}_k - \bar{\eta}_{jk}\bar{\eta}_{kj}\right)}{\bar{\eta}_j\bar{\eta}_k + \bar{\eta}_j\bar{\eta}_{jk}}\,, \quad \text{for } j,\ k = I,\ E, \text{ and } j \neq k.$$

$$\begin{aligned} \text{and} \quad Q(\hat{c}) &\equiv \frac{1}{p_E(1+\lambda)}\left(\lambda(\hat{c} - c_E) - (\mathbf{E}[c_E | c_E \leq \hat{c}] - c_E\right) \\ &= \frac{1}{p_E(1+\lambda)}\left[\lambda(\hat{c} - c_E) - \left(\frac{H(\hat{c})}{G(\hat{c})} - c_E\right)\right]. \end{aligned}$$