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Regulation at home, competition abroad: a theoretical framework

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Abstract

This paper analyses in a hidden characteristic set-up the design of the optimal price for a firm which is a monopolist at home but competes abroad against foreign firms. As long as diseconomies of scope are not too strong, the optimal price is identified. The price rule depends on the sign of the technological relationship between home output and foreign output. With economies of scope, the regulator should set a price below marginal cost, in order to help the firm in the foreign market, and vice-versa with diseconomies of scope. Informational asymmetry introduces a distortion in the price rule, which is usually amplified by the existence of a foreign market.

1. Introduction

In more and more industries traditionally characterised as "natural monopolies" we have recently observed a trend towards the introduction of competition in at least one segment of the business. Electricity generation and supply represent a clear example of segments which are open to competition at least in many countries. However, this process is far from generalised, so that we have markets in which a firm acts as monopolist within a country but has to compete in other markets. EdF, the French electricity monopolist, is an important case of this type, and analogous examples can be found in most countries which keep a regulated home market, but whose "national champions" are allowed to compete abroad.

This situation raises novel issues, in that it can be argued that home regulation should also take into account what the home firm does outside national boundaries. Indeed, when there are technical spillovers (i.e. when costs at home and abroad are not independent), inducing the home firm to produce a large output level might either help or hinder its activities abroad, affecting the profit it can obtain there. The sign of these effects will depend on the relationship between home output and the cost of foreign production.

In this paper we want to tackle this issue in the hidden characteristic setup by Baron and Myerson (1982) [BM] in order to determine optimal regulatory schemes when the regulated firm competes abroad. We thus extend this paper in this direction, showing how the optimal price scheme relates to the original BM case. As long as diseconomies of scope are not too strong, the optimal price is identified.

The price rule depends on the sign of the technological relationship between home output and foreign output. With full information and with economies of scope, the regulator should set a price below marginal cost, in order to help the firm in the foreign market, and vice-versa with diseconomies of scope. Informational asymmetry introduces a distortion in the price rule, which is usually amplified by the existence of a competitive foreign market.

This issue has not so far been considered by the existing literature on regulation (see Armstrong *et al.* (1996) for an excellent survey), which indicates how optimal price should be above marginal cost. The wedge between price and marginal cost is due to the informational asymmetry and to the lower weight attached to profit in the social welfare function. One limitation of this literature that we try to relax is the assumption that the firm produces only one output (in the regulated market). Some papers have been developed on the relationship between regulation and competition, but they consider either the effects of regulated (access) prices on competition (among others, De Fraja, 1999), or the way competition in related (e.g., input) markets can help regulation (Helm and Jenkinson, 1997).

A second stream of literature[1] that is relevant to our analysis is the one on

[1] An important link between the regulation literature and the international trade one is the

strategic trade policies (e.g., Brander and Spencer, 1985). One basic finding of this literature is somehow "inconclusive", in that the optimal trade policy depends on whether competition abroad is in prices (Bertrand) or in output levels (Cournot). With Cournot competition, the home firm should be subsidised, while this conclusion is reversed (a tax becomes optimal) if competition is *á la* Bertrand. In our model we do not have this ambiguity, in that changes in the home price modify the firm's marginal cost, which unambiguously decreases the firm's profit in the foreign market. With respect to this strand of literature we will show the interplay between asymmetric information in the domestic market and the presence of a foreign market with competitors. In our model the domestic regulator faces a trade-off between reducing firm's rent (which requires smaller home production or higher prices) and increasing the foreign profits of the domestic firm.

The paper is organised as follows. Section 2 lays down the model, providing a full information benchmark and stressing features of the equilibrium in the foreign market. The basic set-up is then developed in section 3. Section 4 provides the explicit solution to the model, allowing one to see how the relevant parameters affect equilibrium price, both in full information and with asymmetric information. Section 5 concludes the paper.

2. The model

A multinational serves two countries. In country h (home) the firm is a regulated monopolist and in country f (foreign) it competes against other firms. Two otherwise separate markets are linked by technical links in the cost function of the home "multinational" enterprise (MNE).

The (inverse) demand in market i is $p_i(Y_i)$ where p_i is price and Y_i is the total amount of good consumed in i. The (multinational) firm produces outputs y_h, y_f respectively for market h and f and then $Y_h = y_h$ and $Y_f = y_f + Y_{\text{-}f}$ where $Y_{\text{-}f}$ is output produced by the firm's competitors in f.

Let $C(y_h, y_f; \theta)$ denote the total production cost. We define economies or dis-economies of scope through the sign of the second cross derivative of the cost function. Indeed, we may have

$$\frac{\partial^2 C}{\partial y_h \partial y_f} \lesseqgtr 0 \tag{2.1}$$

literature on the regulation of multinational firms. On this point see Bond and Gresik (1996) and Calzolari (1999).

When this cross derivative is negative, we have economies of scope (producing in one country decreases the marginal cost in the other country), and vice-versa. Notice that if y_h and y_f are homogeneous products, this definition corresponds to the definition of economies of scale.

Finally, the parameter θ is an inverse efficiency measure of the firm: the smaller θ the more efficient is the firm, $C_\theta > 0$, $C_{\theta y_i} \geq 0$ (subscripts indicate partial derivatives) with $i = h,\ f$. Moreover, θ is the industry's private information. The regulator only knows that θ is distributed according to the cumulative distribution $F(\theta)$ and the density $f(\theta) > 0$ over the support $\Theta = \left[\underline{\theta}, \overline{\theta}\right]$ and $f(.)$ satisfies the monotone hazard rate property $d\left[F(\theta)/f(\theta)\right]/d\theta \geq 0$ in Θ. We assume that the MNE's competitors observe y_h before playing the market game, so that we can model competition abroad as a game with asymmetric information. Finally, the MNE, its competitors and the regulator have common knowledge on the model.

If T is the regulatory instrument (tax) employed by the regulator in country h, total MNE's profit is

$$\Pi\left(y_h, y_f; \theta\right) = \sum_{i=h,f} y_i p\left(Y_i\right) - C\left(y_h, y_f; \theta\right) - T \tag{2.2}$$

The regulator maximizes an utilitarian objective function which is a weighted sum of net consumer surplus, of the home firm's profit and taxes (or transfers). Profits earned by the home firm in the home market and abroad are not equally valued (see below) and thus the regulator has to find a way to disentangle the two from the total firm's profit. Given that in principle the cost function is non-separable in the two outputs, defining home and foreign profits can not be done in an unique way[2]. We assume that the splitting rule the regulator has to employ is the following

$$\begin{aligned} \Pi_h\left(y_h; \theta\right) &= y_h p\left(y_h\right) - SAC\left(y_h; \theta\right) - T \\ \Pi_f\left(y_h, y_f; \theta\right) &= y_f p\left(Y_f\right) - IC\left(y_h, y_f; \theta\right) \end{aligned} \tag{2.3}$$

where $SAC\left(y_h; \theta\right) = C\left(y_h, 0; \theta\right)$ is the stand-alone cost (that the firm incurs in case it only produces for the home market) and $IC\left(y_h, y_f; \theta\right) = C\left(y_h, y_f; \theta\right) - C\left(y_h, 0; \theta\right)$ is the incremental cost the firm pays when producing for the foreign market as well. The profit made by the firm in the home market is the one the firm

[2] The issues involved in the problem of allocating common costs is well understood (both in theory and in practice). Notice that most European countries require public utilities to have some "unbundling" of the accounts for different activities.

would gain producing for the only domestic market. On the contrary the foreign profit is the extra-gain the firm can obtain expanding its activities in the foreign market. Note that this profit partition is consistent in the sense that $\Pi_h + \Pi_f = \Pi$.

Let $V(y_h) = \int_0^{y_h} p_h(u)du$ denote gross consumer surplus in country h. Then the welfare function maximized by the regulator is:

$$W = V(y_h) - y_h p(y_h) + T + \alpha\Pi_h + \beta\Pi_f, \tag{2.4}$$

where α and β are the weight for the profits earned by the home firm respectively at home and abroad. The parameter $\alpha < 1$ is the usual weight employed in these models to avoid the Loeb-Magat paradox. As for the value of β, we have at least two possibilities. If the justification for $\alpha < 1$ is the regulator's distributional concern, it would seem natural to set $\beta = 1$: all profits earned at the expense of foreign customers and rival firms represent the firm's income. However, if the justification for $\alpha < 1$ is that a part of the firm's shares are in the hands of foreign shareholders, we should simply set $\beta = \alpha$. We prefer to avoid a clear commitment on any one interpretation, and thus we postpone any decision on this point, and a discussion of these issues (in any case, $\beta \geq \alpha$). For simplicity we assume that the shadow cost of public funds is zero.[3] Finally, for the sake of concreteness, we also assume that consumer surplus in country h is sufficiently high such that the regulator always prefers to have the MNE producing.

Following Baron and Myerson [1982], the regulator sets a welfare maximizing regulatory instrument $T(y_h)$ which is a non linear transfer function of the observable domestic production chosen by the MNE y_h. We make the assumption that the regulator cannot condition the instrument on the firm's foreign activity. This can be justified on several ground. First, regulatory powers are limited within domestic boundaries and regulator h can not directly influence consumption abroad. Second, foreign production may well be difficult to observe.

In the solution of the regulatory game we will employ the Revelation Principle. Thus, we will solve the game in which the regulator sets a menu of contracts $\{y_h(\theta), T(\theta)\}$ conditional on the firm's type and the MNE announces its type $\hat{\theta}$ thus choosing the specific contract $\left\{y_h(\hat{\theta}), T(\hat{\theta})\right\}$.

The timing of the game is the following. The MNE privately learns his type. The regulator sets the welfare maximizing menu of contracts $\{y_h(\theta), T(\theta)\}$. The MNE decides in which countries to produce and announces its type $\hat{\theta}$ to the

[3] Introducing country specific and larger than zero cost of public funds would not alter qualitatively our results.

regulator. Finally, the regulation is enforced, competition in the foreign market takes place and payoffs realize.

Notice that the regulator is here a Von Stackelberg leader with respect to the foreign market activities. Therefore, the regulator cannot use the observation of foreign output[4] to infer the value of θ. This assumption is motivated by the existence of constraints in changing regulatory policies. The fact that regulatory responses are in general substantially slower than industry changes is well documented. More specifically, the general principles of regulatory policies are usually dictated by norms, and even their application cannot be easily modified. For instance, the $RPI - x$ system (the most common way to put into practice the notion of "incentive prices") envisages a price rule which remains fixed for a period of time from three to five years (Armstrong *et al.*, 1997). Therefore, assuming that regulated prices represent longer term commitments relative to market determined prices seems quite natural in this set-up.

2.1. A full information benchmark

Without informational problems, the regulator maximises (2.4) with respect to y_h. Notice that here optimal pricing entails a departure from marginal cost pricing in that the regulator is interested in helping the home firm to gain a profit in the foreign market as well. When *total* profit is bound to be non-negative, the solution requires the home price to be set where

$$p(y_h) = \frac{\partial SAC}{\partial y_h} - (1 - \alpha + \beta)\frac{\partial \Pi_f}{\partial y_h} \tag{2.5}$$

or else - absent distributional concern:

$$p(y_h) = \frac{\partial C}{\partial y_h} - \frac{\partial R_f}{\partial y_h} \tag{2.6}$$

where R_f is the revenue the home firm can obtain in the foreign market. Notice that the sign of $\frac{\partial R_f}{\partial y_h}$ depends on whether outputs are substitutes or complements, and depends thus on the specific model we look at. With diseconomies of scope, increasing home production reduces a firm's competitiveness in foreign markets and therefore $\frac{\partial R_f}{\partial y_h} < 0$; in this case home price will be higher than marginal cost and consumers' interest will give in to the firm's interest in competing in foreign markets.

[4] Even if the regulator could observe that, an analogous result would be obtained if the regulator could not observe the cost levels of foreign firms.

2.2. Foreign production and the regulation game with asymmetric information

In the foreign market firms compete, and we do not impose particular restrictions on the form competition takes. We can thus specify the foreign game with respect to the generic variables x_f, x_f^*, which may be either quantities or prices. If we label by $\widetilde{y_f}$ the equilibrium output level in the foreign market and we set $m(y_h, y_f, \theta) \equiv \frac{\partial C}{\partial y_f}$, the first assumptions we need, which are satisfied in most oligopoly models (including the classical Cournot and Bertrand[5]), can be summarised as

Assumption 1.

$$\frac{\partial \Pi_f(x_f, x_f^*, y_h(\theta), \theta)}{\partial m} < 0 \tag{2.7}$$

$$\frac{\partial \widetilde{y_f}(y_h(\theta), \theta)}{\partial m} < 0 \tag{2.8}$$

Hence, whatever increases marginal cost m decreases the MNE's market share and profit level. Therefore, given that changes in home output y_h affect the foreign game only in that they affect marginal cost m we have:

$$\frac{\partial \Pi_f(x_f, x_f^*, y_h(\theta), \theta)}{\partial y_h} \propto -\frac{\partial^2 C}{\partial y_h \partial y_f} \tag{2.9}$$

$$\frac{\partial \Pi_f(x_f, x_f^*, y_h(\theta), \theta)}{\partial \theta} \propto -\frac{\partial^2 C}{\partial \theta \partial y_f} < 0 \tag{2.10}$$

and

$$\frac{\partial \widetilde{y_f}(y_h(\theta), \theta)}{\partial y_h} \propto -\frac{\partial^2 C}{\partial y_h \partial y_f} \tag{2.11}$$

Notice that the signs of (2.9) and (2.11) depend on whether we have economies or dis-economies of scope.

The solution of the system of first order conditions gives the equilibrium in the foreign market, provided that the firm finds it profitable to be active in the foreign market. Note that as long as costs are non separable, equilibrium output levels in the foreign market depend on the domestic MNE's production y_h (and type θ).

[5] the Cournot case is treated in later sections. See the Appendix for an example with Bertrand competition.

Substituting equilibrium output levels, the profit of a type-θ MNE which announces to be a type $\hat{\theta}$ becomes $\Pi\left(\hat{\theta};\theta\right)=\Pi_h\left(\hat{\theta};\theta\right)+\Pi_f\left(\hat{\theta};\theta\right)$ with

$$\begin{aligned}\Pi_h\left(\hat{\theta};\theta\right) &= y_h(\hat{\theta})\ p\left[y_h(\hat{\theta})\right]-SAC\left(y_h(\hat{\theta});\theta\right)-T(\hat{\theta}) \\ \widetilde{\Pi_f}\left(\hat{\theta};\theta\right) &= \widetilde{y_f}\left(y_h(\hat{\theta})\,;\theta\right)\ p\left[\widetilde{Y_f}\left(y_h(\hat{\theta})\,;\theta\right)\right]-IC\left[y_h,\widetilde{y_f}\left(y_h(\hat{\theta})\,;\theta\right);\theta\right]\end{aligned} \tag{2.12}$$

The different roles that foreign and home profit play call for separate treatment and require separate attention in the regulator's program. The regulatory problem can then be written as follows

$$(\mathcal{P})\quad\begin{cases}\underset{\{y_h(.),T(.)\}}{Max}\ \int_\Theta W\ dF(\theta) \\ \text{s.t.} \\ \Pi\left(\theta;\theta\right)\geq\Pi\left(\hat{\theta};\theta\right)\quad\forall\left(\hat{\theta},\theta\right)\in\Theta\times\Theta\qquad(ICC) \\ \Pi_h\left(\theta;\theta\right)+\Pi_f\left(\theta;\theta\right)\geq\Pi_f^0\left(\theta;\theta\right)\quad\forall\left(\hat{\theta},\theta\right)\in\Theta\times\Theta\ \ (IR)\end{cases}$$

where

$$\Pi_f^0\left(\theta;\theta\right)=y_f^0\ p\left[Y_f^0\right]-IC\left[0,y_f^0;\theta\right]$$

is equilibrium foreign profit when production at home is shut down (in this case foreign and total profits coincide and all the fixed cost is payed on foreign profits) and $y_f^0=\widetilde{y_f}\left(0\,;\theta\right),\ Y_f^0=\widetilde{Y_f}\left(0\,;\theta\right)$. The incentive compatibility constraint (ICC) is standard and assures that the firm prefers to report its type truthfully $(\hat{\theta}=\theta)$. In a way, constraint (IR) is the standard rationality (or participation) constraint; however, notice that the outside option the MNE has is the profit level it can obtain in the foreign market when domestic production were zero, $\Pi_f^0\left(\theta;\theta\right)$. This is a case of regulation, where the firm's reservation profit is type dependent[6]. If this constraint were not met, the firm would be better off closing down its activities at home and producing only for the foreign market[7].

3. Equilibrium domestic price

To characterize equilibrium domestic production we first have to analyze the constraints of the program $(\mathcal{P})$.

[6] The general case is studied by Jullien (1998). A similar case with common agency is analysed in Ivaldi and Martimort (1994) and Calzolari and Scarpa (1999).

[7] We assume that $\Pi_f^0\left(\theta;\theta\right)>0$ within the relevant range of parameters, i.e. that producing at home is not crucial to the survival of the MNE in the foreign market. This is potentially relevant only in the case of economies of scope.

The domestic gains for the firm are (i.e. the gains the MNE obtains from producing abroad and at home as well)

$$G(\theta;\theta) = \Pi_h(\theta;\theta) + \Pi_f(\theta;\theta) - \Pi_f^0(\theta;\theta) \tag{3.1}$$

and constraint (IR) can be rewritten as

$$G(\theta;\theta) \geq 0 \tag{3.2}$$

We have now to deal with the incentive compatibility constraint (ICC) of program $(\mathcal{P})$. Following standard analysis (see Fudenberg and Tirole, 1992) it can be shown that a (ICC) is satisfied if and only if

$$\frac{d\Pi}{d\theta} = \frac{\partial\Pi}{\partial\theta} \tag{3.3}$$

and

$$\frac{\partial^2\Pi}{\partial y_h \partial\theta}\dot{y}_h(\theta) \geq 0 \tag{3.4}$$

where $\dot{y}_h(\theta) \equiv \frac{dy_H}{d\partial\theta}$. In a standard regulation program, the firm only produces for the domestic market and $\frac{\partial^2\Pi}{\partial y_h\partial\theta} = -\frac{\partial^2 C}{\partial y_h\partial\theta} < 0$. The second order condition (3.4) then simply becomes $\dot{y}_h(\theta) \leq 0$. In our model, on the contrary, we have

$$\frac{\partial^2\Pi}{\partial y_h\partial\theta} = \frac{\partial^2\Pi_h}{\partial y_h\partial\theta} + \frac{\partial^2\widetilde{\Pi_f}}{\partial y_h\partial\theta}$$

The first term can be rewritten as $\frac{\partial^2\Pi_h}{\partial y_h\partial\theta} = -\frac{\partial^2 SAC}{\partial y_h\partial\theta} < 0$ but the second term has undetermined sign[8]. In the following we will assume that the standard sign for the single crossing condition holds and we will provide sufficiency conditions for this to happen.

Assumption 2 $\frac{\partial^2\Pi}{\partial y_h\partial\theta} < 0$.

Note that this assumption implies, as it is standard, that domestic (incentive compatible) output must be non-increasing in θ, i.e. $\dot{y}_h(\theta) \leq 0$.

Following the well known first order approach (Guesnerie and Laffont (1984)), instead of analyzing the original program $(\mathcal{P})$ we study a relaxed program $(\mathcal{P}_r)$

[8] Moreover, notice that the previous expression may change sign along Θ. See Araujo and Moreira (1998) for a first attempt of mechanism design with non constant sorting condition.

in which we momentarily neglect constraint (3.4). We will verify ex-post if the solution of $(\mathcal{P}_r)$ verify this constraint.

$$(\mathcal{P}_r)\left\{\begin{array}{l} \underset{\{y_h(.),T(.)\}}{Max} \int_\Theta W\ dF(\theta) \\ \text{s.t.} \\ \frac{d\Pi}{d\theta}=\frac{\partial\Pi}{\partial\theta} \qquad\qquad (ICC_r) \\ G(\theta;\theta)\geq 0 \quad (IR) \end{array}\right.$$

The following proposition characterizes optimal domestic production $y_h(\theta)$ in this case.

Proposition 3.1. *With economies of scope or as long as diseconomies of scope are not too strong (i.e. $y_f^0(\theta)-y_f(\theta)$ is not "too large"), equilibrium domestic price is characterized by the following necessary condition*

$$p(y_h)=\frac{\partial SAC}{\partial y_h}+(1-\alpha)\frac{F(\theta)}{f(\theta)}\left[\frac{\partial^2 SAC}{\partial\theta\partial y_h}-\frac{\partial^2\widetilde{\Pi_f}}{\partial\theta\partial y_h}\right]-(1-\alpha+\beta)\frac{\partial\widetilde{\Pi_f}}{\partial y_h} \tag{3.5}$$

The equilibrium profit of the least efficient firm is equal to the foreign outside opportunity $\Pi_f^0\left(\bar{\theta};\bar{\theta}\right)$ and more efficient firms obtain total profit

$$\Pi(\theta;\theta)=\int_\theta^{\bar{\theta}} C_\theta\left(y_h(u),y_f(u);u\right)du+\Pi_f^0\left(\bar{\theta};\bar{\theta}\right)$$

.

Proof. The first thing we want to show is that $\frac{dG(\theta;\theta)}{d\theta}<0$, so that the only individual rationality constraint we need to consider is $G\left(\bar{\theta};\bar{\theta}\right)\geq 0$. Let us totally differentiate the constraint with respect to θ. The envelope theorem implies that

$$\frac{dG(\theta;\theta)}{d\theta}=$$

$$=\frac{\partial\Pi\left(\hat{\theta}=\theta;\theta\right)}{\partial\hat{\theta}}\frac{\partial\hat{\theta}}{\partial\theta}+\frac{\partial\Pi\left(\hat{\theta}=\theta;\theta\right)}{\partial\theta}-\frac{\partial\Pi_f^0\left(\hat{\theta}=\theta;\theta\right)}{\partial\hat{\theta}}\frac{\partial\hat{\theta}}{\partial\theta}-\frac{\partial\Pi_f^0\left(\hat{\theta}=\theta;\theta\right)}{\partial\theta}$$

It is simple to show that $\frac{\partial\Pi\left(\hat{\theta};\theta\right)}{\partial\hat{\theta}}=0$ (by the envelope theorem) and that $\frac{\partial\Pi_f^0\left(\hat{\theta};\theta\right)}{\partial\hat{\theta}}=0$ (because with $y_h=0$ there is no announcement at all). Also, employing the envelope theorem for y_f and recalling that $y_f=y_f\left(y_h(\hat{\theta});\theta\right)$, we can see that

$\frac{\partial \Pi(\hat{\theta};\theta)}{\partial \theta} = -C_\theta\left(y_h(\theta), y_f(\theta); \theta\right)$ and finally $\frac{\partial \Pi_f^0(\hat{\theta};\theta)}{\partial \theta} = -C_\theta\left(0, y_f^0(\theta); \theta\right)$.We then obtain,

$$\frac{dG(\theta;\theta)}{d\theta} = -C_\theta\left(y_h(\theta), y_f(\theta); \theta\right) + C_\theta\left(0, y_f^0(\theta); \theta\right)$$

The relative magnitude of the values of y_f in the two terms on the RHS depends on whether $C_{y_h y_f} < 0$ or $C_{y_h y_f} > 0$. The previous condition can be rewritten as

$$\frac{dG(\theta;\theta)}{d\theta} = -\int_0^{y_h(\theta)} C_{\theta y_h}\left(u, y_f(\theta); \theta\right) du + \int_{y_f(\theta)}^{y_f^0(\theta)} C_{\theta y_f}(0, u; \theta)\, du \qquad (3.6)$$

With economies of scope, (3.6) is always negative as $y_f(\theta) \geq y_f^0(\theta)$. With diseconomies of scope, $y_f(\theta) \leq y_f^0(\theta)$ and, given $C_{\theta y_i}(\cdot) > 0$, we have

$$\frac{dG(\theta;\theta)}{d\theta} < 0 \qquad (3.7)$$

whenever $y_f^0(\theta)$ is not too large relative to $y_f(\theta)$, i.e. when diseconomies are not too strong. The net rent (3.2) is thus decreasing in θ and making constraint (IR) bind for type $\overline{\theta}$ implies that constraint (IR) is satisfied for all types.

Now we transform the program focusing on $\Pi_h(\theta;\theta)$ as the relevant firm's rent. Constraint (ICC_r) in program $(\mathcal{P}_r)$ can be rewritten as

$$\frac{d\Pi_h}{d\theta} = -\frac{\partial \widetilde{\Pi}_f}{\partial y_h}\dot{y}_h(\theta) - \frac{\partial SAC}{\partial \theta} \qquad (3.8)$$

Now substitute the definition (2.3) of Π_h into the objective function and the relaxed program becomes

$$(\mathcal{P}_r) \quad \begin{cases} Max \int_\Theta \{V(y_h) - SAC(y_h, \theta) - (1-\alpha)\Pi_h + \beta\Pi_f)\}\ dF(\theta) \\ \text{s.t.} \\ \frac{d\Pi_h}{d\theta} = -\frac{\partial \widetilde{\Pi}_f}{\partial y_h}\dot{y}_h(\theta) - \frac{\partial SAC}{\partial \theta} \\ \Pi_h\left(\bar{\theta};\bar{\theta}\right) \geq \Pi_f^0\left(\bar{\theta};\bar{\theta}\right) - \widetilde{\Pi}_f\left(\bar{\theta};\bar{\theta}\right) \quad (IR) \end{cases}$$

Integrating by parts the term $\int_\Theta \{-(1-\alpha)\Pi_h\}\, dF(\theta)$ and using (3.8) the objective function becomes

$$\int_\Theta \left\{V(y_h) - SAC(y_h,\theta) - (1-\alpha)\left[\frac{\partial \widetilde{\Pi}_f}{\partial y_h}\dot{y}_h(\theta) + \frac{\partial SAC}{\partial \theta}\right]\frac{F(\theta)}{f(\theta)} + \beta\Pi_f\right\} dF(\theta) +$$

$$-(1-\alpha)\Pi_h\left(\bar{\theta};\bar{\theta}\right)$$

To maximize this expression w.r.t. y_h we employ calculus of variations. First define $a = V(y_h) - SAC(y_h, \theta) - (1-\alpha)\frac{\partial SAC}{\partial \theta}\frac{F(\theta)}{f(\theta)} + \beta \Pi_f$ and $b = -(1-\alpha)\frac{\partial \widetilde{\Pi_f}}{\partial y_h}\dot{y}_h(\theta)\frac{F(\theta)}{f(\theta)}$. The Euler's equation can then be written as

$$\frac{\partial a}{\partial y_h} = \frac{\partial b}{\partial \theta}$$

Which, rearranging, becomes (3.5). Given the position of $\Pi_h\left(\bar{\theta};\bar{\theta}\right)$ in the welfare function, the transfer will make this constraint binding. ■

The above result holds under the condition that diseconomies between home output and foreign output are not "too strong", i.e. that the difference $y_f^0(\theta) - y_f(\theta)$ is not "too large". This term is the difference between what the firm would produce abroad without operating in the home market, and what it produces abroad in equilibrium (i.e., while serving the home market as well). The domestic activity increases the firm's cost, and thus reduces its foreign output level. If this effect is limited, Proposition 3.1 holds because (3.6) holds. For instance, if foreign output and home output are homogeneous (so that total cost only depends on the sum $y_h + y_f$) the above condition boils down to $y_f^0(\theta) < y_h(\theta) + y_f(\theta)$, an extremely reasonable condition in our context. We will soon provide another example.

Under this condition we thus have the price rule (3.5), which represents the optimal regulatory scheme[9]. To provide an intuition, it is useful to distinguish the two cases of economies and dis-economies of scope separately.

Dis-economies of scope. Absent asymmetric information and distributional problems ($\alpha = \beta = 1$), the optimal price is simply the difference between *total* marginal cost and the derivative of foreign revenue relative to home output $\left(\frac{\partial R_f}{\partial y_h}\right)$. With Cournot competition, $\frac{\partial R_f}{\partial y_h} < 0$ so that the firm will be induced to reduce home production and price *above* total marginal cost, in order to help its competitiveness in foreign markets. In both cases, $p(y_h) > \frac{\partial SAC}{\partial y_h}$, which might be interpreted indicating that there is an optimal cross subsidy that the regulator should provide the national firm: some consumers' surplus is traded off for some (foreign) profit.

When some distributional concern is present ($\alpha < 1$), the weight of the term $\frac{\partial \Pi_f}{\partial y_h}$ is higher as long as $\beta > \alpha$. Therefore, when the home welfare function weighs home profits (obtained at the expense of home consumers) less than profits obtained abroad, the wedge between price and marginal cost widens.

[9] If $y_f^0(\theta) >> y_f(\theta)$ then $sign\left(\frac{dG}{d\theta}\right)$ is endogenous and with common techniques nothing can be said on how to satisfy constraint (IR).

Furthermore, when informational asymmetries matter we have a second order term - in line with Baron-Myerson (1982) - which again is the difference between the direct effect on stand alone cost and the indirect effect on foreign profit. This informational wedge is zero for the most efficient firm ($F(\underline{\theta}) = 0$).

Economies of scope. In this case, what changes is the sign of the term $\frac{\partial \Pi_f}{\partial y_h}$ in (3.5), which is negative with dis-economies of scope and is positive in the current case. This means that the optimal price tends to be lower than marginal cost. Indeed, with $\alpha = \beta = 1$ and Cournot competition, $\frac{\partial R_f}{\partial y_h} > 0$ and the firm will be induced to increase home production and price *below* total marginal cost, in order to exploit scope economies and improve competitiveness in the foreign market. In both cases, $p(y_h) < \frac{\partial SAC}{\partial y_h}$, which captures the fact that with economies of scope the defense of consumers' interest and firms' profits do not necessarily clash.

Exactly as in the previous case, the presence of asymmetric information widens the wedge between price and marginal cost.

Finally, notice that in both cases (3.7) implies that in equilibrium we have

$$\Pi\left(\bar{\theta}; \bar{\theta}\right) = \Pi_f^0\left(\bar{\theta}; \bar{\theta}\right) \tag{3.9}$$

This indicates that - unlike the BM case - here even the least efficient firm enjoys a positive rent, but this is entirely due to his ability to compete in the foreign market. No additional rent accrues to him in the home market.

We must now turn to check whether the second order condition $\dot{y}_h(\theta) \leq 0$ is met. Given

$$p(y_h) = \frac{\partial SAC}{\partial y_h} + (1-\alpha)\frac{F(\theta)}{f(\theta)}\left[\frac{\partial^2 SAC}{\partial\theta\partial y_h} - \frac{\partial^2 \widetilde{\Pi}_f}{\partial\theta\partial y_h}\right] - (1-\alpha+\beta)\frac{\partial\widetilde{\Pi}_f}{\partial y_h}$$

this requires determining under what conditions $\frac{\partial p(y_h)}{\partial\theta} \geq 0$.

$$\begin{aligned}\frac{\partial p(y_h)}{\partial\theta} &= \frac{\partial^2 SAC}{\partial\theta\partial y_h} + (1-\alpha)\frac{\partial\frac{F(\theta)}{f(\theta)}}{\partial\theta}\left[\frac{\partial^2 SAC}{\partial\theta\partial y_h} - \frac{\partial^2\widetilde{\Pi}_f}{\partial\theta\partial y_h}\right] + \\ &\quad (1-\alpha)\frac{F(\theta)}{f(\theta)}\left[\frac{\partial^3 SAC}{\partial\theta\partial y_h\partial\theta} - \frac{\partial^3\widetilde{\Pi}_f}{\partial\theta\partial y_h\partial\theta}\right] - (1-\alpha+\beta)\frac{\partial^2\widetilde{\Pi}_f}{\partial\theta\partial y_h}\end{aligned} \tag{3.10}$$

The first two terms are positive, given the monotonicity of the hazard rate, and $\frac{\partial^2 SAC}{\partial\theta\partial y_h} - (1-\alpha+\beta)\frac{\partial^2\widetilde{\Pi}_f}{\partial\theta\partial y_h} > 0$ if the difference $\beta - \alpha$ is not too large". Moreover,

$\frac{\partial^2 \widetilde{\Pi_f}}{\partial\theta\partial y_h} \propto \lambda$. However, the sign of the third term is hard to determine in general, and one must assume that the direct effect $\frac{\partial^2 SAC}{\partial\theta\partial y_h} + (1-\alpha)\frac{\partial \frac{F(\theta)}{f(\theta)}}{\partial\theta}\left[\frac{\partial^2 SAC}{\partial\theta\partial y_h} - \frac{\partial^2 \widetilde{\Pi_f}}{\partial\theta\partial y_h}\right]$ (which is positive) is strong enough in order to guarantee the concavity of the regulatory program.

4. A model with an explicit solution

In this section we employ a simple model which an be explicitly solved, allowing us to explore in greater detail how foreign competition affects equilibrium price. Let the cost function for the regulated MNE be

$$C = \theta(y_h + y_f) + \lambda y_h y_f \tag{4.1}$$

with $\lambda > (<) 0$ respectively with dis-economies or economies of scope between domestic and foreign outputs, the cost function of foreign firm(s) $C^* = \theta^* y_f^*$ and the foreign and domestic inverse demand functions respectively $p_f = a - b(y_f^* + y_f)$ and $p_h = a - by_h$.

Competition abroad takes the form of a Cournot game which leads to the following optimal outputs for the foreign market

$$y_f^* = \frac{a-(2\theta^*-\theta)}{3b} + \frac{\lambda}{3b}y_h$$

$$y_f = \frac{a-(2\theta-\theta^*)}{3b} - \frac{2\lambda}{3b}y_h \tag{4.2}$$

Substituting for y_f and y_f^*, the foreign profit can be written as a function of the domestic output:

$$\Pi_f\left(y_h(\hat{\theta});\theta\right) = \frac{\left[a-2\theta+\theta^*-2\lambda y_h(\hat{\theta},\theta)\right]^2}{9b}$$

Notice that $a-2\theta+\theta^*-2\lambda y_h(\hat{\theta}) > 0$ for $y_f > 0$, so that - in line with intuition - we have

$$\frac{\partial\Pi_f\left(y_h(\hat{\theta});\theta\right)}{\partial y_h} = -4\lambda\frac{\left[a-2\theta+\theta^*-2\lambda y_h(\hat{\theta},\theta)\right]}{9b} \propto -\lambda \tag{4.3}$$

Substituting (4.2) into (4.1), we can see that the cost function considered by the firm - in deciding $\hat{\theta}$ - and by the regulator - when setting the incentive mechanism - is now the following

$$C = \frac{1}{3b}\left[\theta\left(a - 2\theta + \theta^*\right) + \left(3b\theta + \lambda\left(a - 4\theta + \theta^*\right)\right) y_h - 2\lambda^2 y_h^2\right] \tag{4.4}$$

It is interesting to point out that this function is now concave in y_h. This is because $\frac{\partial y_f}{\partial y_h} \propto -\lambda$: an increase in y_h induces a change in y_f which is inversely proportional to λ so that, whichever the sign of λ, the marginal cost of y_h decreases.

We can now take as benchmark the case when the regulator is fully informed (FI), and compare it with the asymmetric information solution (AI). Substituting the previous expressions into the MNE's profit, simple calculations allow us to obtain the domestic optimal quantity and price

$$y_h^{FI}(\theta) = \frac{9\,b(\,a - \theta)}{9\,b^2 - 8\,\lambda^2(1 - \alpha + \beta)} - (1 - \alpha + \beta)\frac{4\lambda\,(a - 2\theta + \theta^*)}{9\,b^2 - 8\,\lambda^2(1 - \alpha + \beta)} \tag{4.5}$$

$$p^{FI}(\theta) = \theta + (1 - \alpha + \beta)\frac{4\lambda\left[a - 2\theta + \theta^* - 2\lambda y_h(\hat{\theta}, \theta)\right]}{9b}$$

which, given (4.5) becomes:

$$p^{FI}(\theta) = \theta + (1 - \alpha + \beta)\frac{4\lambda\left[b(a - 2\theta + \theta^*) - 2\lambda(a - \theta)\right]}{9b^2 - 8\lambda^2(1 - \alpha + \beta)} \tag{4.6}$$

Notice that, substituting (4.5) into (4.2), we obtain

$$y_f^{FI} = \frac{b\left[a - 2\theta + \theta^*\right] - 2\lambda(a - \theta)}{9b^2 - 8\lambda^2(1 - \alpha + \beta)} \tag{4.7}$$

Notice that for $y_f^{FI} > 0$, $p^{FI}(\theta) > \theta$ if and only if $\lambda > 0$.

In order to have sensible comparisons we will consider parameters such that the second order condition for the FI program is satisfied:

$$9\,b^2 - 8\,\lambda^2(1 - \alpha + \beta) \geq 0 \tag{4.8}$$

In case of asymmetric information, the foreign game remains the same as described above, but we can employ the result in Proposition 3.1 to calculate the optimal quantity for the regulated domestic market:

$$y_h^{AI}(\theta) = y_h^{FI}(\theta) - (1 - \alpha)\frac{F(\theta)}{f(\theta)}\frac{9b - 8\lambda}{9b^2 - 8\lambda^2(1 - \alpha + \beta)} \tag{4.9}$$

The following Lemma shows that in the case of substitutes all assumptions of "not too strong" substitutability needed in the general model are here always satisfied. Indeed, they are implied by the second order condition for the regulation program. This suggests that those requirements were in fact not too demanding.

Lemma 4.1. *If the second order condition for the FI regulation program (4.8) and the standard monotone hazard rate assumption ($\partial\left(\frac{F(\theta)}{f(\theta)}\right)/\partial\theta \geq 0$) are satisfied, then the quantity in (4.9) is the optimal domestic quantity for any level of substitutability and complementarity.*

Proof. The second order condition for the FI regulator's program (4.8) can be rewritten as

$$|\lambda| \leq \lambda^{SOC} \equiv \frac{3b}{4}\frac{\sqrt{2}}{\sqrt{1-\alpha+\beta}} \tag{4.10}$$

The case of economies of scope ($\lambda < 0$) is simple. Assumption 2 is satisfied as long as $\frac{8\lambda-9b}{9b} < 0$ which is always true for $\lambda < 0$; moreover in Proposition 3.1 $\lambda < 0$ implies that $\frac{dG}{d\theta} < 0$.

In the case of dis-economies of scope ($\lambda > 0$), Assumption 2 can be written as $\lambda \leq \frac{9b}{8}$. It is simple to verify that $\frac{9b}{8} \geq \lambda^{SOC}$ for any $\beta \geq \alpha > 0$, which means that (4.8) implies that Assumption 2 holds. Second, the condition for "not too strong" substitutability in the proof of Proposition 3.1 becomes, with algebraic manipulations

$$(-3b+2\lambda)\frac{y_{h(\theta)}}{3b} < 0$$

which is equivalent to $\lambda < \frac{3b}{2}$. Obviously $\lambda^{SOC} < \frac{3b}{2}$, so that the result follows.

Finally, it remains to check that the second order condition in the AI program (3.10) is satisfied. The condition $\frac{dp(\theta)}{d\theta} \geq 0$ now writes as

$$1 - \frac{8\lambda\left(1-\alpha+\beta\right)\left(b-\lambda\right)}{9b^2-8\lambda^2\left(1-\alpha+\beta\right)} + (1-\alpha)\frac{\partial\frac{F(\theta)}{f(\theta)}}{\partial\theta}\frac{b\left(9\,b-8\lambda\right)}{9b^2-8\lambda^2(1-\alpha+\beta)} \geq 0$$

It is straightforward to show that the sum of the first and the second terms is positive.. In fact,

$$1 - \frac{8\lambda\left(1-\alpha+\beta\right)\left(b-\lambda\right)}{9b^2-8\lambda^2\left(1-\alpha+\beta\right)} \gtreqqless 0 \Leftrightarrow 9b - 8\lambda(1-\alpha+\beta) \lesseqqgtr 0$$

and we already showed that it must be $9b \geq 8\lambda(1-\alpha+\beta)$. Hence. the standard monotone hazard rate assumption $\frac{\partial \frac{F(\theta)}{f(\theta)}}{\partial \theta} \geq 0$ implies condition (3.10). ■

The second order FI condition (4.8) introduces both a lower and an upper limit to the value of λ. The reason why this happens is related to equation (4.4), which shows how the cost function, once we consider how y_f depends on y_h, is concave in y_h, and how the degree of concavity depends on λ^2. Thus, an increase in the absolute value of λ jeopardises the concavity of the objective function.

Given this result we can now determine the optimal regulated price using (4.9):

$$\begin{aligned} p^{AI}(\lambda,\alpha,\beta) &= \theta + 4\lambda(1-\alpha+\beta)\frac{[b(a-2\theta+\theta^*)-2\lambda(a-\theta)]}{9b^2-8\lambda^2(1-\alpha+\beta)} + \\ & + (1-\alpha)\frac{F(\theta)}{f(\theta)}\frac{b\,(9\,b-8\lambda)}{9b^2-8\lambda^2(1-\alpha+\beta)} \end{aligned}$$

i.e.:

$$p^{AI}(\lambda,\alpha,\beta) = p^{FI}(\theta) + (1-\alpha)\frac{F(\theta)}{f(\theta)}D \tag{4.11}$$

where $D \equiv \frac{9b-8\lambda}{9b^2-8\lambda^2(1-\alpha+\beta)}$.

It is easy to see that with $\alpha = \beta$:

$$p^{AI}(\lambda,\alpha) = \theta + 4\lambda\frac{[b(a-2\theta+t)-2\lambda(a-\theta)]}{9b^2-8\lambda^2} + (1-\alpha)\frac{F(\theta)}{f(\theta)}\frac{b\,(9\,b-8\lambda)}{9b^2-8\lambda^2}$$

while absent any distributional concern ($\alpha = \beta = 1$) we have

$$p^{AI}(\lambda) = \theta + 4\lambda\frac{b\,(a-2\theta+\theta^*)-2\lambda(a-\theta)}{9\,b^2-8\,\lambda^2}$$

which in this case obviously coincides with p^{FI}.

4.1. Comparison I: the role of asymmetric information

Let us now analyse the role played by the presence of informational asymmetry. The equilibrium price (4.11) is an expression where three effects interact. Indeed, we know that:

$$p^{AI}(y_h) = \frac{\partial SAC}{\partial y_h} + (1-\alpha)\frac{F(\theta)}{f(\theta)}\left[\frac{\partial^2 SAC}{\partial\theta\partial y_h} - \frac{\partial^2 \Pi_f}{\partial\theta\partial y_h}\right] - (1-\alpha+\beta)\frac{\partial \Pi_f}{\partial y_h}$$

and we can see that informational asymmetry matters in three respects. The first two are within square brackets and are

- $\frac{\partial^2 SAC}{\partial\theta\partial y_h}$, which in our case is equal to 1;

- $-\frac{\partial^2 \Pi_f}{\partial\theta\partial y_h}$, which given (4.3), is

$$-\frac{\partial^2 \Pi_f}{\partial\theta\partial y_h} = -\frac{8\lambda}{9b} \propto -\lambda$$

- A third effect goes through $\frac{\partial \Pi_f}{\partial y_h}$, which depends on y_h, which in turn depends on whether or not we have asymmetric information. Therefore, in our case this effect is equal to:

$$(1-\alpha+\beta)\left[8\,\lambda^2(1-\alpha)\frac{F(\theta)}{f(\theta)}\frac{9\,b-8\lambda}{9b\,(9b^2-8\lambda^2(1-\alpha+\beta))}\right] > 0$$

The first and the third effect are always positive, while the second one depends on λ. However, the sum of them is always positive, as one can see from (4.11); this is obvious when $\lambda < 0$, while if $\lambda > 0$ this indicates that the first and the third effect prevail on the second one.

The following proposition states this result and, employing the second term on the r.h.s. of conditions (4.9) and (4.11), it summarizes the comparative statics of the distortionary terms with respect to the relevant parameters, i.e. the degree of (dis-)economies of scope (λ) and the profit weights α, β.

Proposition 4.2. *For any value of λ, $p^{AI} > p^{FI}$.*
The asymmetric information distortion D

- *decreases with α and increases with β (increases in the difference $\beta - \alpha$);*

- *increases with λ if $\lambda > \tilde{\lambda} \equiv b\left(\frac{9}{8} - \frac{\sqrt{9(1-\alpha+\beta)-8}}{8\sqrt{1-\alpha+\beta}}\right) > 0$ (strong dis-economies of scope). Notice that $\tilde{\lambda} \leq \lambda^{SOC}$ and $\frac{\partial\tilde{\lambda}}{\partial b} > 0$, $\frac{\partial\tilde{\lambda}}{\partial\alpha} > 0$, $\frac{\partial\tilde{\lambda}}{\partial\beta} < 0$*

- *decreases with λ as long as $\lambda < \tilde{\lambda}$ (mild dis-economies of scope, or else economies of scope).*

Proof. Given that (4.8) implies $9b - 8\lambda > 0$, inequality $p^{AI} > p^{FI}$ simply follows from (4.11). Moreover, take the distortionary term $(1-\alpha)\frac{F(\theta)}{f(\theta)}D$ from (4.9) or (4.11) and define $k \equiv 1 - \alpha + \beta$. Differentiating we have $\frac{\partial D}{\partial k} = \frac{8(9b-8\lambda)\lambda^2}{(9b^2-8k\lambda^2)} \geq 0$ as long as $\lambda \leq \frac{9}{8}b$. It is straightforward to verify that this condition is always implied by the second order condition.

Moreover, $\frac{\partial D}{\partial \lambda} \propto -9b^2 + 2\lambda(9b - 4\lambda)k$. It is then obvious that $\frac{\partial D}{\partial \lambda} < 0$ if $\lambda \leq 0$.

When $\lambda > 0$, on the contrary $\frac{\partial D}{\partial \lambda} > 0$ iff $\tilde{\lambda} \leq \lambda \leq \bar{\lambda}$ with $\tilde{\lambda} \equiv b\left(\frac{9}{8} - \frac{\sqrt{9(1-\alpha+\beta)-8}}{8\sqrt{1-\alpha+\beta}}\right)$ and $\bar{\lambda} = b\left(\frac{9}{8} + \frac{\sqrt{9(1-\alpha+\beta)-8}}{8\sqrt{1-\alpha+\beta}}\right)$. Then one can easily show that the upper bound $\lambda \leq \bar{\lambda}$ is always implied by the second order condition. Moreover, as it is $\tilde{\lambda} \leq \lambda^{SOC}$, we can have both the cases: $\tilde{\lambda} \leq \lambda \leq \lambda^{SOC}$ with $\frac{\partial D}{\partial \lambda} > 0$ and $\lambda \leq \tilde{\lambda} \leq \lambda^{SOC}$ with $\frac{\partial D}{\partial \lambda} < 0$. ■

The informational rent paid to the firm out of home market's surplus is proportional to the output produced at home. This is why $\frac{\partial D}{\partial \alpha} < 0$: as standard (see Baron and Myerson, 1982) a higher weight of home profits induces a higher equilibrium output and hence a higher rent for the MNE.

The interpretation of the effect of β is less obvious. Notice that when the firm obtains a larger profit abroad the regulator is able to reduce the rents that have to be paid to the MNE at home without violating the participation constraint. Therefore, there is an implicit trade off between home profits and foreign profits: reversing the above argument, we can thus see that a higher level of β will make domestic rents less desirable for the regulator, who will thus reduce domestic equilibrium output. In other terms, foreign profits and home profits are "equally good" in meeting the participation constraint, but the asymmetry between α and β introduces the regulator to prefer foreign profits. A larger value of β makes this effect stronger.

Finally, the informational distortion decreases with λ unless λ is positive and "large". To see why this may be the case it is useful to consider how the marginal cost of home production varies with λ given the foreign market game. Indeed - using (4.4) - we have

$$\frac{\partial^2 C}{\partial y_h \partial \lambda} = \frac{a - 4\theta + \theta^* - 8\lambda y_h}{3b}$$

which decreases with λ and might even become negative with λ sufficiently large.

4.2. Comparison II: the role of competition.

Let us now analyse the consequences of our generalisation of the Baron-Myerson model to the case in which the regulated firm faces competition in a foreign market. The Baron-Myerson price (without competition in a foreign market) is

$$p^{BM} = \theta + (1-\alpha)\frac{F(\theta)}{f(\theta)}$$

so that, using (4.11) we have

$$p^{AI}(\lambda,\alpha,\beta) - p^{BM} = 4\lambda \Big[(1-\alpha+\beta)\tfrac{[b(a-2\theta+\theta^*)-2\lambda(a-\theta)]}{9b^2-8\lambda^2(1-\alpha+\beta)} + - (1-\alpha)\tfrac{F(\theta)}{f(\theta)}\tfrac{2(b-\lambda(1-\alpha+\beta))}{9b(9b^2-8\lambda^2(1-\alpha+\beta))}\Big] \tag{4.12}$$

This expression is obviously equal to zero when $\lambda = 0$. To interpret this expression, it is useful to point out that, relative to the standard case, foreign competition introduces both

- a change in the optimal full-information price, which is measured by the term $(1-\alpha+\beta)4\lambda\frac{b(a-2\theta+\theta^*)-2\lambda(a-\theta)}{9b^2-8\lambda^2(1-\alpha+\beta)}$; its sign is the same as λ given the non negativity of y_f^{FI} (see expression (4.7));
- an additional informational distortion, measured by the second term in square brackets, $-(1-\alpha)\frac{F(\theta)}{f(\theta)}\frac{8\lambda[b-\lambda(1-\alpha+\beta)]}{9b(9b^2-8\lambda^2(1-\alpha+\beta))} \propto -\lambda\,[b-\lambda(1-\alpha+\beta)]$

The first effect is straightforward: absent informational problems, foreign competition should induce the regulator to decrease home price when there are economies of scope, and vice-versa[10].

The sign of the informational effect depends on whether or not

$$\lambda < \lambda' \equiv \frac{b}{1-\alpha+\beta}$$

With $\lambda < 0$, this condition is met and the two effects go in opposite directions: the informational asymmetry would drive towards a price higher than in the standard Baron-Myerson case. This happens because a lower level of y_h decreases the ability of the MNE to obtain rents.

[10] In the appendix we show that this effect naturally holds also with Bertrand competition.

With dis-economies of scope, the same holds when λ is small enough. However, notice that $\lambda' < \lambda^{SOC}$, so that there might be admissible values of λ such that the additional informational distortion changes sign and goes in the same direction as the first effect. To see why this may be the case, it is useful to consider how the marginal cost of home production varies with λ given the foreign market game. First of all, recall that (4.4) is concave in y_h and that

$$\frac{\partial^2 C}{\partial y_h^2} = -\frac{2\lambda^2}{3b} < 0$$

increases in absolute value with λ. In other terms, the regulator induces the firm to produce a large level of output at home because "overall" marginal cost of home production is decreasing. This holds with $\lambda < 0$ (when we have no conflicting effects), but also when $\lambda > 0$. When λ is large, this effect more than compensates the presence of a foreign market where the MNE can obtain a profit. In this latter case, we can be sure that $p^{AI}(\lambda, \alpha, \beta) - p^{BM} > 0$.

However, in general, the optimal price might be higher or lower than p^{BM}, depending on which effect dominates.

Up to now we assumed that there was a unique foreign competitor. It is however, interesting to analyse the effects of increasing foreign competition on the regulated price. Consider n rival firms in the foreign market. Standard computations yield outputs in the foreign market for the multinational firm and its n competitors

$$\begin{aligned} y_f &= \frac{a + n\theta^*}{(n+2)b} - \frac{(n+1)}{(n+2)b}\left[\theta + \lambda y_h\right] \\ y_f^* &= \frac{a - 2\theta^*}{(n+2)b} + \frac{\theta + \lambda y_h}{(n+2)b} \end{aligned}$$

so that equilibrium foreign price is

$$p_f = \frac{a + n\theta^* + \theta + \lambda y_h}{n+2}$$

When $n \to \infty$, price converges to $p_f|_{n\to\infty} = \theta^*$. Thus, in this limit case the multinational serves the foreign market only if $\theta + \lambda y_h \leq \theta^*$.

The MNE's profit in the foreign market is

$$\Pi_f = \frac{\left(a + n\theta^* - (n+1)(\theta + \lambda y_h)\right)^2}{(n+2)^2 b}$$

Thus
$$\frac{\partial \Pi_f}{\partial y_h} = -2(n+1)\lambda \frac{a + n\theta^* - (n+1)(\theta + \lambda y_h)}{(n+2)^2 b} \propto -\lambda$$

and the marginal profitability of home output (in terms of profit obtained in the foreign market) decreases with the number of competitors if and only if[11] $\lambda < 0$

$$\frac{\partial^2 \Pi_f}{\partial y_h \partial n} = \lambda \frac{2}{(n+2)^3 b} \left[na - \theta^*(3n+2) + 2(n+1)(\theta + \lambda y_h) \right] \propto \lambda \tag{4.13}$$

In the full information case, proceeding as above it is easy to show that the optimal price can be written as

$$p_h^{FI}(n) = \theta + (1 - \alpha + \beta)\lambda \frac{2(n+1)\left[b(a - (n+1)\theta + n\theta^*) - \lambda(n+1)(a - \theta)\right]}{b^2 s(n) - 2\lambda^2(1 - \alpha + \beta) r(n)}$$

with $s(n) = (n+2)^2$, $r(n) = (n+1)^2$. Moreover, the second order condition is

$$2\lambda^2(1 - \alpha + \beta) r(n) - b^2 s(n) < 0$$

Again this guarantees that for $y_f^{FI}(n) > 0$, $p_h^{FI}(n) > \theta$ if and only if $\lambda > 0$.

>From (2.5) it appears that n affects equilibrium price only via $\frac{\partial \Pi_f}{\partial y_h}$, so that (4.13) implies that

$$\frac{\partial p_h^{FI}(n)}{\partial n} = (1 - \alpha + \beta) \frac{\partial^2 \Pi_f}{\partial y_h \partial n} \propto \lambda$$

This entails that a more competitive foreign market will induce the (fully informed) regulator to increase price at home when $p_h^{FI}(n) > \theta$ and vice-versa. With $\lambda > 0$, the regulator implicitly provides the home firm a subsidy, in order to allow it to better compete in the foreign market; this subsidy is higher, when competition abroad gets tougher.

With asymmetric information, equilibrium domestic output and price then become

$$y_h^{AI}(\theta) = y_h^{FI}(\theta) - (1 - \alpha) \frac{F(\theta)}{f(\theta)} \frac{bs(n) - 2\lambda r(n)}{b^2 s(n) - 2\lambda^2 (1 - \alpha + \beta) r(n)}$$

$$p^{AI}(n, \lambda, \alpha, \beta) = p^{FI}(\theta) + (1 - \alpha) \frac{F(\theta)}{f(\theta)} \frac{bs(n) - 2\lambda r(n)}{b^2 s(n) - 2\lambda^2 (1 - \alpha + \beta) r(n)} \tag{4.14}$$

[11] Notice that the expression in square brackets in (4.13) is positive for any value of θ^* such that $y_f^* \geq 0$.

which is equal to (4.11) when $n = 1$ and again $p^{AI} > p^{FI}$. Let us now see how the optimal price varies with the number of foreign rivals.

Starting from the full-information price, we have already stressed that the effect of increasing n has the same sign as λ.

The informational distortion $D_n \equiv \frac{bs(n)-2\lambda r(n)}{b^2 s(n)-2\lambda^2(1-\alpha+\beta)r(n)}$ varies with n as follows:

$$\frac{\partial D_n}{\partial n} = -\lambda \frac{4(1-\alpha)b^2(n+2)(n+1)\left[b-\lambda(1-\alpha+\beta)\right]}{\left(b^2\left(n+2\right)^2-2\lambda^2\left(1-\alpha+\beta\right)\left(n+1\right)^2\right)^2} \propto \quad (4.15)$$

$$\propto -\lambda\left[b-\lambda(1-\alpha+\beta)\right]$$

With economies of scope ($\lambda < 0$), the above expression is obviously positive. With dis-economies of scope ($\lambda > 0$) we can have an ambiguity. With λ sufficiently small, the expression in square brackets in (4.15) is positive, so that $\frac{\partial D_n}{\partial n} < 0$. However, there exist values of λ which satisfy the second order condition and Assumption 2, but such that $b - \lambda(1-\alpha+\beta) < 0$.

This means that in general an increase in n may affect the full-information price and the informational distortion in opposite ways. The total effect of an increase in n on the optimal price will depend on the interplay between these two effects, and the effect on the informational wedge can reverse the effect on the full information price.

Notice that a peculiar implication if these results is the following. With symmetric information the price will be different from marginal cost; the presence of asymmetric information typically operates in the opposite direction, driving the price back towards marginal cost, paradoxically helping allocative efficiency.

5. Conclusions

This paper has highlighted how the mere existence of a foreign market, where regulated firms compete with foreign rivals, modifies both full information optimal price and the informational distortion that emerges in Baron-Myerson type models. Several themes, however, remain open for future research.

For instance, one of them is the issue of incentives to invest. There is an extensive literature which - not without ambiguity - points out how competition might contribute to the internal efficiency of the firm. Analysing how competitive pressure drives the firms to exert greater effort, compensating the *underinvestment* problem pointed out by Laffont e Tirole (1986) represents an immediate potential extension of this line of research.

A second possibility would be to look at the relationship between regulation and competition when the regulated firms competes in a second domestic market (rather than abroad). Indeed, in many markets competition and regulation co-exist, and their interplay is still largely unexplored. This situation is at least as common as the problem we have studied, as the case of electricity (where vertically integrated firms are monopolists in distribution or in transmission, but compete in the generation market) or telecoms (where one typically observes a monopoly in the *last mile* while competition is extensive in other segments).

Several commentators have suggested that competitors of a dominant firm should be compensated with forms of asymmetric regulation. However, one could argue that a regulated price, set in order to help the firm against its competitors would reduce the rents the firm obtains in the regulated market at the expense of consumers. An analysis of the relative merit of these arguments is a task that we leave to future research.

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6. Appendix

In this Appendix we want to show that even with Bertrand competition any decrease in the marginal cost the firm bears in the foreign market game is advantageous to the firm itself.

Without loss of generality, let us consider a Bertrand duopoly in the foreign market with linear demand and costs. To avoid extreme cases, we take the case of differentiated products. Notice that with homogeneous goods a lower marginal cost is even more critical to a firm's profitability. Good i faces a demand function

$$q_i = a - bp_i + sp_j \tag{6.1}$$

with $i,\ j = 1, 2\ ,\ i \neq j$. The obvious restriction $|s| \leq b$ applies. Let the cost function for the regulated MNE (firm 1) be

$$C_1 = \theta(y_h + y_1) + \lambda y_h y_1 \tag{6.2}$$

with $\lambda > (<)0$ respectively with dis-economies or economies of scope between domestic and foreign outputs. Let us define

$$c_1 \equiv \theta + \lambda y_h$$

The cost function of foreign firm is $C_2 = c_2 y_2$

Therefore, firms have linear costs in the outputs sold in this market, and that the relevant profit functions in this market game are

$$\pi_i = (p_i - c_i)(a - bp_i + sp_j) \tag{6.3}$$

Taking first order conditions w.r.t. prices, we have the reaction functions

$$p_i = \frac{a + bc_i + sp_j}{2b} \tag{6.4}$$

Equilibrium prices are:

$$p_i^* = \frac{a(2b+s) + 2b^2 c_i + sbc_j}{4b^2 - s^2}$$

This implies that the price-cost difference can be written as:

$$p_i^* - c_i = \frac{a(2b+s) - (2b^2 - s^2)c_i + sbc_j}{4b^2 - s^2}$$

Equilibrium demand is

$$q_i^* = b\frac{a(2b+s) - (2b^2 - s^2)c_i + sbc_j}{4b^2 - s^2}$$

so that an increase in firm i's marginal cost decreases both the price-cost margin and output sold by firm i. In equilibrium, firm i's profit is

$$\pi_i^* = b\left(\frac{a(2b+s) - (2b^2 - s^2)c_i + sbc_j}{4b^2 - s^2}\right)^2 \tag{6.5}$$

so that - given $q_i^* > 0$ - equilibrium profit decreases with c_i

$$\frac{\partial \pi_i^*}{\partial c_i} = -2b\left(\frac{a(2b+s) - (2b^2 - s^2)c_i + sbc_j}{4b^2 - s^2}\right)\frac{2b^2 - s^2}{4b^2 - s^2} < 0$$

This obviously implies that

$$\frac{\partial \pi_i^*}{\partial y_h} = \frac{\partial \pi_i^*}{\partial c_i}\frac{\partial c_i}{\partial y_h} \propto -\lambda$$

i.e., any increase in the home output produced by the MNE increases the profits obtained in the foreign market if and only of there are economies of scope in the firm's cost function.