Common Market with Regulated Firms*

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Abstract

We examine the effect of bilateral trade in a concentrated industry under Cournot competition, when firms are regulated by national agencies who care about national social welfare. We allow for differences in costs and market sizes, and for asymmetric information between regulatory agencies and regulated firms. A national regulatory policy may or may not be publicly observed by foreign competitors. We show that it is optimal to allow states to subsidize their domestic firms: bilateral trade improves the allocative efficiency and reduces the agency costs of regulation. Strategic trade policy effects that appear when regulatory contracts are public are beneficial to both states and reduce incentive costs as well as allocative inefficiencies. Results extend to the case of segmented markets with export costs when states are allowed to use export subsidies as well as to regulate domestic production.

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Save as otherwise provided in this Treaty, any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favoring certain undertaking of the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the common market. (Article 92, Treaty establishing the European Economic Community)

1 Introduction

The European integration process as well as the recent GATT negotiations show the common interest of states to limit the scope of state interventionism in trade policy. The economists' mistrust of trade policy is rooted both in the traditional international trade literature (see for example Corden (1974) and Krugman and Obstfeld (1988)) and in the more recent analysis of strategic trade policy under imperfect competition (see Helpman and Krugman (1989) for a comprehensive exposition). In fact, the effective policy of the European Commission is more flexible than what article 92 of the EEC Treaty suggests.[1] In particular, aids concerning activities of general interest or intended to reduce monopoly pricing distortions can obtain derogations.[2] In this paper, we examine protected monopolies such as telecommunications, energy, domestic transportation or postal services. As a result of the creation of the common market along with the deregulation process at work since a few years, these sectors should be opened to competition in a near future (or are already in such a process, as the airline industry or the telecommunications industry). Because of the particular nature of most of these industries (in particular, the fact that regulated domestic firms face universal service requirements), it is likely that state intervention will not disappear, although reduced through the deregulation process. It is also likely that these sectors will be subject to a limited degree of competition and that the main participants will be the previously protected monopolies[3]. The role of national subsidy policies in a common market under imperfect competition thus remains a sensitive topic

[1]For an exposition of the European Union policy in this respect, see *European Economy 48*.

[2]See article 90 of the EEC Treaty, and also article 77 on transportation.

[3]Obviously the deregulation process also triggers entry of noneuropean firms. We shall ignore this aspect in the paper.

that we address here. Given the theoretical level of analysis adopted in the present paper, we view our contribution mostly as a first account of the costs and benefits of integration in regulated industries and of the interactions between national regulations in a common market.

We consider a two-country model and restrict ourself to partial equilibrium analysis. Initially, each domestic market is served by a regulated protected monopoly. Each firm produces under constant marginal cost for a linear demand, possibly with private information on the marginal cost. Only production is verifiable and each firm is regulated through a menu of linear contracts (each contract within the menu specifies a subsidy rate and a lump sum transfer). Regulatory agencies maximize a national social welfare function with redistributive concerns in favor of consumers. In this context, the optimal regulation is characterized by a trade-off between efficiency and agency costs. States then agree to create a common market. In the main part of the paper, this creates a single integrated market in which firms compete under Cournot competition. Within this common market, national firms are still subsidized by their respective national regulators. We shall illustrate the following main points:

- When firms are regulated at the national level, the creation of a common market (with no transportation costs) improves the allocative efficiency.

- Trade reduces the agency costs of regulation, first, through a correlation effect related to the introduction of competition, second, through an allocative effect related to the reallocation of production across states.

- Strategic trade policy effects that appear when subsidy rates are public reduce the allocative inefficiencies and increase national welfares. They act as a coordination device for the regulators.

- Moreover, public disclosure of subsidy rates allows the regulators to reduce the agency costs.

In our common market model, states should be allowed to subsidize domestic producers because this reduces prices. Because of Cournot competition, both states produce, with higher market share for the most efficient firm. The price then settles between the marginal costs of the two firms.[4] In particular, the high cost country subsidizes its firm so as to induce production, despite its negative profit margin, because it benefits from lower prices. The low cost country benefits from the export revenues. In the case of segmented markets with transportation costs, the results also hold when policy makers can isolate exports in total production. However, if they can't do so, either because regulation is imperfect or because of legal restrictions, the open market economy involves excessive trade. Moreover, for transportation costs larger than the production cost differential, prices increase in both countries when markets are open.[5] Bilateral trade may then reduce social welfare.

Agency costs appear when production costs are private information of the firms. They correspond to the extra profits (above the reservation levels) or informational rents that have to be left to the firms by regulatory agencies in order to maintain incentive compatibility of the allocation implemented. The creation of the common market affects these rents in two ways depending on the correlation between the costs of the two firms. When costs are perfectly correlated, low cost firms face a stronger competitive pressure than high cost firms. Overstating its cost becomes less attractive to a firm, which allows the regulatory agency to adjust lump-sum transfers and reduce incentive costs. When the marginal costs of the firms are independently distributed, the creation of a common market reallocates production by reducing high cost firms' production and raising low cost firms' production. This again reduces informational rents.

Precommitment effects are more complex. For our concern, the most relevant work is the paper by Brander and Spencer (1985) which emphasizes the national incentives to subsidize exporting producers when they compete in a Cournot manner on foreign markets. The equilibrium result of this game can be analyzed as a prisoner's dilemma and states would benefit from jointly reducing subsidies. The initial work of Brander and Spencer has been extended to take into account agency costs related to asymmetric information between the firms and the policy makers (see Maggi (1992), Brainard and

[4]The price is thus above the competitive price. However, it is a striking feature of our model, that the common market price is below the price that would result under perfect competition and state interventions (which is the highest marginal cost). This is due to the Cournot competition assumption.

[5]The excessive trade result is well known under no regulation (see Brander and Krugman (1983)), but the increase in prices is specific to imperfectly regulated industries.

Martimort (1992 and 1995), and in a different context Kuhn (1989)). The main conclusion is that agency costs may mitigate the prisoner's dilemma but do not invalidate the basic premise of the analysis.

We isolate precommitment effects by contrasting the situation where regulatory contracts are secret and the situation where they are public. Regulation takes the form of a menu of linear contracts within which the firm selects one contract; this stage corresponds to unobserved negotiations in the secret contract case, while, in the public contract case, we assume the ultimate choice of contract is observed.[6] In a common market situation, the analysis differs from Brander and Spencer's analysis because governments take into account the national consumers' surplus. Indeed both states will benefit from precommitment effects and they agree on desired changes in productions. States face a coordination problem that strategic policy effects help to solve; contract disclosure induces a coordination effect rather than a strategic effect in the above sense. Moreover, under imperfect information, by forcing the regulated firm to disclose any subsidy rate that it chooses within the menu offered, a regulatory agency can reduce agency costs: the reaction of the rival to the announcement of the policy helps to reduce the attractiveness of misreporting the cost. Therefore public disclosure of contracts improves social welfare.

The paper is organized as follows. Section 2 presents the basic model and the closed economy benchmark. Section 3 focuses on perfect information, and examines the allocative effects of the common market and the strategic trade policy effects. Section 4 studies the effect on informational rents of both secret and public regulatory contracts. Section 5 extends the analysis to segmented markets and transportation costs. Finally, section 6 concludes.

2 The basic model

We study an economy composed of two countries $i = 1, 2$. We take a partial equilibrium point of view and focus on the market for a particular good produced by regulated utilities. In each country, a single regulated firm produces to satisfy the local demand, which is assumed to be linear and equal to:

$$q_i^d = \lambda_i \left(a - p_i \right).$$

[6] This assumption is not innocuous and is discussed in the conclusion.

The elasticity of demand is the same for both countries, but we allow for different market sizes. Consumers' surplus is given by:

$$S_i = \int_0^{q_i^d} p_i(u)du - p_i q_i^d = \frac{\lambda_i}{2}(a - p_i)^2 = \frac{\left(q_i^d\right)^2}{2\lambda_i},$$

where q_i^d is domestic consumption.

The firm produces with constant marginal cost equal to θ_i in country i. We first assume that costs are public information ; we then study the effect of asymmetric information about costs. Each firm is regulated by a national agency through a linear tariff: s_i is a unitary subsidy and t_i a lump-sum transfer from the firm to the government.

Let q_i^s denote national production. The firm's net profit is given by:

$$\Pi_i = (p_i - \theta_i + s_i)q_i^s - t_i.$$

We also let $\pi_i = (p_i - \theta_i)q_i^s$ denote the gross profit of the firm. National agencies maximize a social welfare function which is assumed to be a weighted sum of consumers' net surplus (surplus minus transfers to the firm) and firm's net profit:

$$\begin{aligned} W_i &= S_i - s_i q_i^s + t_i + \alpha \Pi_i \qquad \text{where } \alpha \leq 1 \\ &= S_i + \pi_i - (1-\alpha)\Pi_i. \end{aligned}$$

In this simple model, the regulatory policy under perfect information in the closed economy constitutes a standard benchmark: the government designs the regulation so that the price is set at marginal cost, $p_i = \theta_i$, and the firm's profit is equal to the reservation level that we normalize to 0: this requires to set $s_i = a - \theta_i$, which induces a production $q_i = \lambda_i (a - \theta_i)$, and to fix t_i so that $\Pi_i = 0$. National social welfare in country i is then equal to:

$$W_i^{closed} = \frac{\lambda_i}{2}(a - \theta_i)^2.$$

When markets are open to bilateral trade, the two firms produce for a single common[7] market with total demand equal to $(\lambda_1 + \lambda_2)(a - p)$. We shall use the notation $\Lambda = \lambda_1 + \lambda_2$. So the inverse demand is:

$$p = a - \frac{q_1 + q_2}{\Lambda}.$$

[7] We study the segmented market case in section 5.

In the paper, we maintain the assumption that the differences between the two countries are small, and the deadweight loss associated to pure monopoly is large (this avoids corner solutions):

Assumption : $\theta_1 \leq \theta_2$ (under perfect information), $\frac{\theta_i}{a}$ is small, the cost differential $\frac{\theta_2-\theta_1}{\theta_2+\theta_1}$ is small, as well as $\frac{\lambda_i-\lambda_j}{\Lambda}$.

Competition in the common market is modeled through a two-stage game. At the first stage, governments propose subsidy policies simultaneously and non-cooperatively to their firms, firms accept or reject. If a firm rejects, it cannot produce. In the second stage, firms compete in quantities in the common market.[8] We shall distinguish between three cases:

- No regulation.
- Regulation schemes are secret. In this case, the marginal subsidy rate of one firm is not observed by the rival before it chooses production.
- Regulations schemes are publicly observed once they are signed, before production decisions.

3 Open market with perfect information

In the absence of regulation, the simple game of Cournot competition on the common market results in an equilibrium price $p = \frac{1}{3}\left(a + \theta_i + \theta_j\right).$

When firms are regulated under secret regulation policies, a regulatory contract between a government and a firm is known only by the contracting parties. The value s_i of the unitary subsidy in country i cannot influence the quantity produced by the firm in country j. In this setting, the choice of a secret subsidy policy is equivalent for the government to the choice of a production q_i and of a lump sum transfer. We can thus solve this game as a one-stage game in which governments choose productions and tax all the profits above the reservation level.

Government in country i maximizes domestic social welfare:

[8]In our model, the common market representation is equivalent to a segmented market representation where firms produce for the domestic market and export on the foreign market. This is mentioned in Ben-Zvi and Helpman (1992). In section 5, we extend the analogy at a formal level, taking into account transportation costs.

$$\frac{\lambda_i}{2\Lambda^2}(q_1+q_2)^2+(a-\frac{q_1+q_2}{\Lambda}-\theta_i)q_i.$$

The equilibrium price and quantities of the game are:

$$\begin{aligned} p_i &= \frac{1}{2}(\theta_i+\theta_j), \\ q_i^s &= \lambda_i(a-\theta_i)+\frac{\lambda_j}{2}(\theta_j-\theta_i). \end{aligned}$$

The price settles between the two marginal costs and is independent of market sizes. Comparing the price with the case of no regulation and with the competitive price θ_1, we obtain:

Proposition 1 *In a common market, bilateral regulation reduces the price compared to the case with no regulation: allowing states to subsidize their firms Pareto dominates a ban on national regulations. The price is however larger than its competitive level.*

The most interesting feature is that despite the fact that the market price is below its production cost θ_2, the firm in country 2 produces: *high cost states choose to induce their firms to produce at a price below marginal cost.* The reason is that, for a given quantity brought to the market by the foreign firm, an increase in domestic production reduces the price and therefore implements a transfer from the foreign firm to consumers. It follows that the optimal price may be below marginal cost.

Comparing open regulated markets and protected markets, we find:

$$W_i^s - W_i^{closed} = \frac{\lambda_i+2\lambda_j}{8}(\theta_1-\theta_2)^2.$$

We thus obtain:

Proposition 2 *Opening the markets to competition with national regulations is welfare improving.*

Results are for the main part in line with perfect competition: *both price and production decrease in the high cost country, production increases in the low cost country.* Country 1 faces higher prices but the export profits compensate for the consumers' loss. Country 2 benefits from lower prices. It produces at a negative margin unlike perfect competition but the loss is outweighed by the benefits from lowering the price. Notice that the gains from trade are larger for the country with the smallest market.

The price level is however larger then its level under perfect competition. This is due to the imperfect nature of competition between state-firm pairs. States do not internalize the effect of their subsidies on the foreign consumers' surplus. This can be seen as a *free rider* problem; each state would like the other state to subsidize more, but states cannot coordinate in their subsidy policies.

We should also point out that if firms compete in prices under Bertrand competition, firm 1 would serve the whole market at price θ_2. *Cournot competition leads to lower prices than Bertrand competition.* The reason is that when firms compete in quantities, the high cost country can reduce the market price by only raising marginally its market share, while under price competition it can only reduce the price below its marginal cost by serving the whole market. This reduction in the cost of intervention by state 2 increases the competitive pressure on state 1, resulting in lower prices.

One may however, look at the case of secret regulation with some scepticism to the extent that national industrial policies are generally publicly known. Consequently, we now investigate the case where regulation schemes are observed by all participants before the firms produce. We see this situation as the most reasonable scenario since it reflects a situation where regulation policy design is an heavy process that occurs only from time to time whereas firms interact quite often, with a good knowledge of regulatory environments. In this context, each state can affect the quantity chosen by the foreign firm through the announcement of the subsidy rate: there are precommitment effects. States design their policies taking into account the effect on their domestic firm's behavior but also on the response of the foreign firm (see Brander and Spencer (1985) and Eaton and Grossman (1986)).

The situation is modeled as a two-stage game, where states first design subsidy rates (s_1, s_2) (and lump-sum transfers) and then firms compete on the common market. The equilibrium is easily characterized; it involves equilibrium unitary subsidies, price and productions:

$$s_i = \frac{1}{2\Lambda}\left(2\lambda_i(a-\theta_i) + \lambda_j(\theta_j - \theta_i)\right),$$

$$
\begin{aligned}
p_i &= \frac{1}{2}\left(\theta_i + \theta_j\right), \\
q_i^p &= \lambda_i(a - \theta_i) + \frac{\lambda_i + 2\lambda_j}{2}(\theta_j - \theta_i).
\end{aligned}
$$

A first immediate result is that the price is the same as for secret contracts. The main reason is that while the low cost country increases its subsidy when contracts are public, the high cost country reduces its subsidy. Indeed $\frac{\partial W_i}{\partial q_j} = \frac{\lambda_i q_j - \lambda_j qi}{\Lambda^2}$. At the secret contracts equilibrium, this reduces to $\frac{1}{2}(\theta_i - \theta_j)$. Precommitment effects act in the same direction. The low cost country makes positive profits and would like to reduce the rival's production. The high cost country prefers to raise the rival's production. Given that quantities are strategic substitutes, both countries desire an increase in the low cost country production and a reduction of the high cost country production. As a result, precommitment effects induce mostly a substitution of productions. While the fact that price is unchanged comes from our particular modeling assumptions, the conclusion that precommitment effects have a low impact on prices in a common market seems robust.

If we compare the total quantities produced by one firm, we have:

$$
q_i^p - q_i^s = \frac{\Lambda}{2}\left(\theta_j - \theta_i\right).
$$

The change in production due to the public nature of regulation schemes is proportional to the cost differential.

Proposition 3 *The country with the lowest cost has a larger market share when contracts are public, compared to secret contracts.*

It follows that precommitment effects improve allocative efficiency. These conclusions are in marked contrast with the literature on precommitment effects of export subsidies when firms export in a third country; here quantity substitution solves a coordination problem between states, while there, the situation involves conflicting interests, in the spirit of the prisoner's dilemma.

Since prices do not depend upon whether regulation is secret or public, so does gross consumers' surplus. Welfare comparisons between these two situations thus depend only on the changes in profits and can be assessed, using:

$$
W_i^p - W_i^s = \frac{\Lambda}{4}\left(\theta_2 - \theta_1\right)^2.
$$

Proposition 4 *With a common market, public regulation Pareto dominates secret regulation.*

Public regulation is preferred to secret regulation because precommitment effects shift production from the "inefficient" firm (which has a negative profit margin) to the "efficient" firm, increasing profit in both countries. This effect is greater (for a fixed total market size) the greater is the cost differential. If countries are identical, public and secret regulation are equivalent.

4 Asymmetric Information: Informational Rents Effects

4.1 The basic model

In regulatory environments, firms typically have access to better information about their costs than regulatory agencies: there are informational asymmetries. The regulatory contracts then leave profits to the firm because the agency lacks the information necessary to extract these profits while maintaining incentives at the firm level: we refer to these extra profits as the informational rent or the agency cost.

To focus on this issue, we assume a symmetric model ($\lambda_1 = \lambda_2 = 1$). Firm i perfectly knows its own cost parameter θ_i, while the states only have prior beliefs, namely that θ_i is randomly drawn by nature in $[\underline{\theta}, \underline{\theta} + 1]$, according to the uniform distribution.[9] Firms are regulated according to a menu of linear subsidies, $(t_i(\widetilde{\theta}_i), s_i(\widetilde{\theta}_i))$,where $\widetilde{\theta}_i$ is a message sent by firm i that can be interpreted as the choice of a transfer/subsidy rate pair within the menu.

We shall consider two cases: cost parameters may be independently drawn, or they may be equal and therefore perfectly correlated. For the independent costs case, we assume that θ_i is private information of firm i only. Given the symmetry assumption, we shall omit the country's index whenever it is not necessary.

[9] The demand function is linear and attention must therefore be devoted to checking that all quantities and prices found are ex-post (i.e. for all possible values of costs) positive. This may be a problem when informational distortions are large compared to the true value of costs, which is why we will have to consider $\underline{\theta}$ high enough. In any case, a is assumed to be large compared to costs as previously.

As a benchmark, let us consider the case of closed economies. Under autarchy, one can easily show that, in our linear model, a regulation based on a menu of linear schemes is equivalent (in terms of implementable allocations) to a regulation where the agency proposes a menu of quantities $q(\widetilde{\theta})$ and lump-sum transfers $t(\widetilde{\theta})$ (see Laffont and Tirole (1993)). We can thus derive the optimal allocation using a regulation scheme designed in terms of quantities. Using the revelation principle, the problem is to find the regulatory contract that maximizes expected domestic social welfare, subject to revelation constraints and participation constraints. This is a direct application of Baron-Myerson (1982), where the FOC for the revelation constraint is given by:

$$\frac{d\Pi(\theta)}{d\theta} = -q(\theta),$$

and the participation constraint reduces to:

$$\Pi(\underline{\theta} + 1) = 0,$$

where $\Pi(\theta)$ is the net profit of the firm when its cost is θ, and $q(\theta)$ is the induced production.

The optimal subsidy coefficient, production and resulting price are:

$$\begin{aligned} s^A(\theta) &= a - \theta - 2(1-\alpha)(\theta - \underline{\theta}), \\ q^A(\theta) &= a - \theta - (1-\alpha)(\theta - \underline{\theta}), \\ p^A(\theta) &= \theta + (1-\alpha)(\theta - \underline{\theta}). \end{aligned}$$

As we can see, the price is higher than under perfect information. *Imperfect information leads the states to induce less production than under perfect information.* Except for the lowest cost, the price is above marginal cost and the firm obtains a positive rent. The term $(1-\alpha)(\theta - \underline{\theta})$ is the social cost of the expected marginal increase in informational rents accrued to the firm (to maintain incentive compatibility) when the production of type θ is increased. It is increasing with the cost because the firm tends to overstate its cost, and decreasing with α, the weight of profit in the social welfare objective function.

Coming back to the case of a common market, we will consider as before two possibilities. For the secret regulation case, we assume that the menu offered and the choice within the menu by the regulated firms are not observed by the competitor. For the public regulation case, we assume that the menu is not observed, but once the firm has chosen a linear contract within the menu, this linear contract is observed by the competitor. In other words, we assume that the implemented linear contract is observed.[10]

We are going to study the following situations in the context of a common market:

- Secret and public regulations with independently drawn cost parameters.

- Secret and public regulations with perfect correlation.

4.2 Independent costs

4.2.1 Secret regulation

When contracts are not observed by the rival before the production decisions are taken, regulation policies are secret (cannot be credibly publicly disclosed) and as in the case of a closed economy, one can solve the model directly using quantity regulation since quantities and marginal subsidies are one-for-one related (for fixed foreign firm' production). An equilibrium will be characterized by two functions $q_i(\theta_i)$ and $q_j(\theta_j)$.

Let $q_j^e = E\{q_j(\theta_j)\}$ denote the expected production of the rival firm when it reveals its type. When the firm in country i has cost θ and faces a regulatory policy $(t_i(.), q_i(.))$, it earns a profit from pretending it has cost $\tilde{\theta}$, given by:

$$\Pi_i(\tilde{\theta}, \theta) = -t_i(\tilde{\theta}) + q_i(\tilde{\theta}) \left[a - \theta - \frac{q_i(\tilde{\theta}) + q_j^e}{2} \right].$$

Revelation constraints are then equivalent to the following conditions:

$$\frac{d\Pi_i(\theta)}{d\theta} = -q_i(\theta) \text{ and } \dot{q}_i(\theta) \leq 0.$$

Optimizing national social objectives subject to the incentive constraints determines $q_i(.)$ as a best response to q_j^e; the symmetric equilibrium can then be characterized and is summarized in:

[10] One may view here the menu as part of the negotiation process and the choice within the menu as the outcome of the negotiation process, which is observed once agreed upon.

Lemma 1 *Under imperfect information, secret contracts and independent costs, the symmetric equilibrium production and price are given by:*

$$q^{SI}(\theta) = a - \theta - \frac{5-4\alpha}{3}(\theta - E\{\theta\}) - (1-\alpha)(E\{\theta\} - \underline{\theta}),$$

$$p^{SI}(\theta_1, \theta_2) = \frac{\theta_1 + \theta_2}{2} + \frac{5-4\alpha}{3}(\frac{\theta_1 + \theta_2}{2} - E\{\theta\}) + (1-\alpha)(E\{\theta\} - \underline{\theta}),$$

and there exists $\widehat{\theta} \in]\underline{\theta}, E\{\theta\}[$ *such that the price is below the perfect information common market price iff* $\frac{\theta_1+\theta_2}{2} < \widehat{\theta}$.

Proof. See appendix. ■

To assess the effects of the opening of markets, one can write the equilibrium quantity as:

$$q^{SI}(\theta) = q^A(\theta) - \frac{2-\alpha}{3}(\theta - E\{\theta\}),$$

while the change in price from autarchy is:

$$p^{SI}(\theta_1, \theta_2) - p^A(\theta_1) = \frac{2-\alpha}{3}(2\theta_2 - \theta_1 - E\{\theta\}).$$

Opening the market thus leads to a reallocation of production in favor of the most efficient firm. The effect is similar to the perfect information case but limited by the lack of information of one state on the production cost of the foreign firm. In particular, for some cost parameters' values, the price may increase for both countries or decrease for both countries.

From a welfare point of view, there are two effects at work here. The first effect comes from an efficiency gain due to the reallocation of production between the two firms. The second effect is more subtle and results from the change in informational rents caused by the reallocation of production: *because the creation of a common market improves the allocative efficiency, it reduces informational rents.*

Indeed the incentive costs for a given quantity profile of the domestic firms is unchanged, given by: $\frac{d\Pi_i(\theta)}{d\theta} = -q_i(\theta)$. Incentives rents are necessary to deter low cost firms from pretending they have high costs. If production for high cost firms is reduced, the prospects from overstating one's own cost are smaller and the informational rent can then be reduced. Now, when exploiting the benefits from trade under full information about their firms, states are led to reduce the production of high cost firms (which are likely to face a more efficient competitor) and to increase the production of low cost firms (which are likely to face a less efficient competitor). Ex-post efficiency considerations are therefore in line with the desire to limit informational rents: they imply lower production for the high cost firm, thereby reducing the social loss due to agency costs. We summarize our conclusions as follows:

Proposition 5 *Under imperfect information, secret contracts and independent costs, the creation of a common market is welfare improving. It doesn't affect the expected production, but a firm produces more if its cost is smaller than the mean cost* $E\{\theta\}$, *and less otherwise. It reduces the informational rent of the firms for all cost parameter values.*

Proof. See appendix. ■

4.2.2 Public regulation with independent costs

Let us now assume that contracts are public and let us consider the following scenario. First, nature secretly and independently determines the cost parameters, privately learned by each firm. Regulators in both countries simultaneously design subsidy policies, $(t_i(.), s_i(.))$, as a function of their own firms' announcements; each producer accepts (or refuses) the subsidy policy and then announces a cost parameter $\tilde{\theta}_i$; then the resulting policy $(t_i(\tilde{\theta}_i), s_i(\tilde{\theta}_i))$ is publicly observed. Finally, each producer chooses his production decision, based on his own subsidy policy and on his observation of the rival's subsidy policy.

Given the independence assumption, the subgame following the observation of public subsidies is a Bayesian game, since producer i has only beliefs upon producer j's cost parameter, which prevents him from perfectly forecasting what producer j will produce. The public disclosure of subsidy policies, however, can be used by each producer to update his beliefs upon his opponent's cost; in this sense, public subsidies serve as *signalling devices*[11] for one country as well as *precommitment devices.* The game can a priori have multiple equilibria depending upon how much information is conveyed by the

[11] The fact that trade policy can be used as a signalling device is emphasized by Collie and Hviid (1992) and Qiu (1992).

signalling phase. We are going to focus on the existence and characterization of a separating symmetric equilibrium.

Formally, a separating equilibrium in the game of subsidy design and production decisions is characterized by:

- equilibrium subsidy policies, $(t_i^*(.), s_i^*(.))$,
- truthful revelation by each firm to its respective regulator,
- equilibrium productions $q_i(\theta_i, s_i, s_j)$ contingent on the firm's true cost, on the linear coefficient of the subsidy policy that it faces and on the observed coefficient of the rival's subsidy policy,
- and beliefs on the opponent's cost parameter based upon the observation of the opponent's subsidy policy.

In a separating equilibrium, the linear coefficient of the subsidy policies has to be strictly monotonic and beliefs at the Cournot competition stage have to be degenerate: observing s_i, firm j has to believe that $\theta_i = (s_i^*)^{-1}(s_i) \equiv \sigma_i(s_i)$, at least provided that $s_i \in s_i^*([\underline{\theta}, \underline{\theta} + 1])$, otherwise beliefs are not determined. We denote by $\Sigma = \{\sigma_1(.), \sigma_2(.)\}$ the posterior beliefs.

Consider the subgame of Cournot competition when coefficients s_i and s_j have been publicly disclosed, in such a separating equilibrium. Firms draw inferences about types so that j thinks i's cost is $\sigma_i(s_i)$ and i thinks j's cost is $\sigma_j(s_j)$. For given beliefs Σ, one can characterize equilibrium quantities at the Cournot stage, $q_i^\Sigma(\theta_i; s_i, s_j)$ and $q_j^\Sigma(\theta_j; s_i, s_j)$, as being best responses to each other and one can deduce the resulting price $p^\Sigma(\theta_i, \theta_j, s_i, s_j)$. From these, it is possible to compute firm i's utility from pretending it has cost $\tilde{\theta}_i$ when its cost is θ_i, when it faces a subsidy policy $(t_i(.), s_i(.))$ possibly different from the equilibrium policy, and when it conjectures that firm j faces the equilibrium policy and draws inference about s_i using the equilibrium function $\sigma_i(.)$. The FOC of the revelation constraint, derived in the appendix, must now be written in expectation:

$$\frac{d\Pi_i}{d\theta_i} = -\mathbf{E}_{\theta_j}\left[q_i^\Sigma(\theta_i, s_i(\theta_i), s_j^*(\theta_j))\right].$$

Optimizing national social welfare under the revelation and participation constraints yields a characterization of the equilibrium in policy design, summarized in the following Lemma.

Lemma 2 *Under imperfect information, public contracts and independent costs, the symmetric separating equilibrium is characterized by equilibrium unitary subsidy, production and price given by:*

$$s^{PI}(\theta) = \frac{a-\theta}{2} - \frac{2B^*-1}{2}(\theta - E\{\theta\}) - \frac{3}{2}(1-\alpha)(E\{\theta\} - \underline{\theta}),$$

$$q_i^{PI}(\theta_i, \theta_j) = a - \frac{4}{3}(1+B^*)\theta_i + \frac{2}{3}(1+B^*)\theta_j + \frac{2B^*-1}{3}E\{\theta\} - (1-\alpha)(E\{\theta\} - \underline{\theta}),$$

$$p^{PI}(\theta_1, \theta_2) = \frac{\theta_1+\theta_2}{2} + \frac{2B^*-1}{3}(\frac{\theta_1+\theta_2}{2} - E\{\theta)) + (1-\alpha)(E\{\theta\} - \underline{\theta}),$$

where B^* is the positive solution of equation: $14x^2 - (35-24\alpha)x - 13 + 6\alpha = 0$, *and therefore satisfies* $2B^* - 1 > 0$.

Proof. See appendix. ■

Note first that the incentive constraint takes a local form similar to the secret contract case: the slope of the informational rent is given by the expected production of the firm. The equilibrium value of this slope can then be compared with the secret contracts case:

$$\mathbf{E}_{\theta_j}\left[q_i^{\Sigma}(\theta_i, s_i^*(\theta_i), s_j^*(\theta_j))\right] - q_i^{SI}(\theta_i) = \frac{4}{3}(1-\alpha-B^*)(\theta_i - E\{\theta\}),$$

where $(1-\alpha-B^*) < 0$. Consequently, public disclosure reduces the informational rent because *the allocative effect pointed out above is reinforced by the signalling / commitment strategy*, as is explained below.

This result is illustrated on the following figures.

Comparing ex-post quantities and price under secret and public regulation for any pair (θ_i, θ_j), we have:

$$q_1^{PI}(\theta_1, \theta_2) - q_1^{SI}(\theta_1) = \frac{4}{3}(1-\alpha-B^*)\theta_1 + \frac{2}{3}(1+B^*)\theta_2 + \frac{2}{3}(B^*+2\alpha-3)E\{\theta\},$$

$$p^{PI}(\theta_1, \theta_2) - p^{SI}(\theta_1, \theta_2) = \frac{2}{3}(B^*+2\alpha-3)(\frac{\theta_1+\theta_2}{2} - E\{\theta)).$$

One can check that $B^* < 3-2\alpha$ if α is smaller than some threshold $\widehat{\alpha}$ between 0 and 1 and that $(1-\alpha-B^*) < 0$.

Public disclosure of regulatory contracts involves a substitution of production that differs from the one achieved in the case of secret contracts.

Figure 1: Informational rent slopes with independent costs

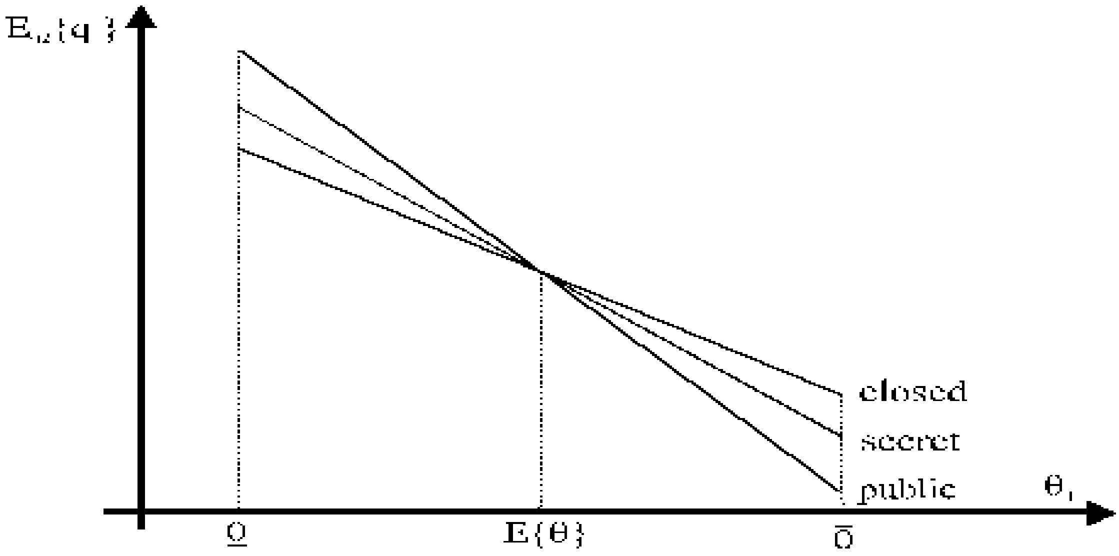
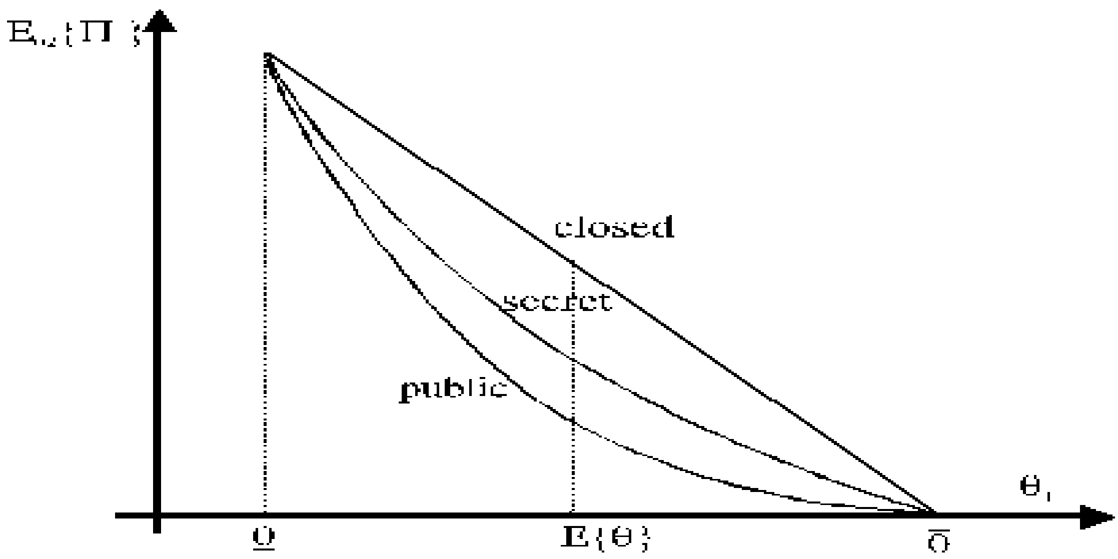


Figure 2: Informational rents with independent costs



The intuition goes as follows. There is a first effect which is simply the *strategic effect*. It is two-fold here: *commitment* through the annoucement of the subsidy rate and *signalling.*[12] Under perfect information, we showed that strategic trade policy effects lead each state to induce more production from low cost firms, and vice versa. Moreover, states agree on the direction of the desired changes in productions. In our signalling game, states follow the same logic and use public disclosure of contracts to commit to increase the production levels of low cost firms, and to reduce the production of high cost firms. Signalling effects go in the same direction: each state has incentives to distort beliefs downward (to lower σ_j for state i by increasing the subsidy rate) when the domestic firm's cost is below the average, and upward (by reducing the subsidy rate) if it is above the average. This leads to a steeper equilibrium production profile than under secret contracts; if this were the only effect, it would also result in a steeper price function.

The second effect is an indirect equilibrium effect due to the *signalling of the productivity.* Since unitary subsidies are publicly observed, firm j will react to the announcement of the cost of the domestic firm that is revealed by the signal. If θ_i is low, firm i's productivity and then production are high: the foreign firm j wants to decrease its production, because it faces an efficient competitor. This reflects into:

$$\frac{\partial q_j^{PI}}{\partial \theta_i} = -\frac{1}{2}\frac{\partial q_i^{PI}}{\partial \theta_i} > 0.$$

Concerning the equilibrium price function, this effect works in the opposite direction than the commitment effect and tends to reduce the slope of the price profile with respect to θ_i:

$$\frac{\partial p^{PI}}{\partial \theta_i} = -\frac{1}{4}\frac{\partial q_i^{PI}}{\partial \theta_i},$$

while:

$$\frac{\partial p^{SI}}{\partial \theta_i} = -\frac{1}{2}\frac{\partial q_i^{SI}}{\partial \theta_i},$$

since under secret contracts the rival firm cannot react to the cost.

[12]Notice that the marginal impact of the subsidy rate of type θ_i on the foreign firm production is stronger than under full information because firm j's beliefs are affected according to $\sigma_j(s_i)$ which is decreasing.

Figure 3: Prices with independent costs, α close to 0

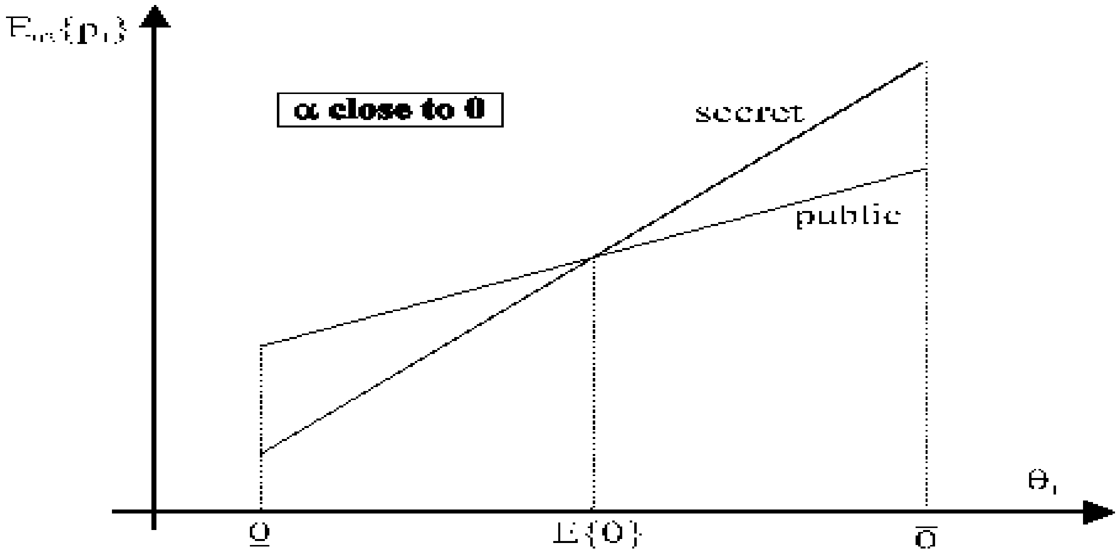
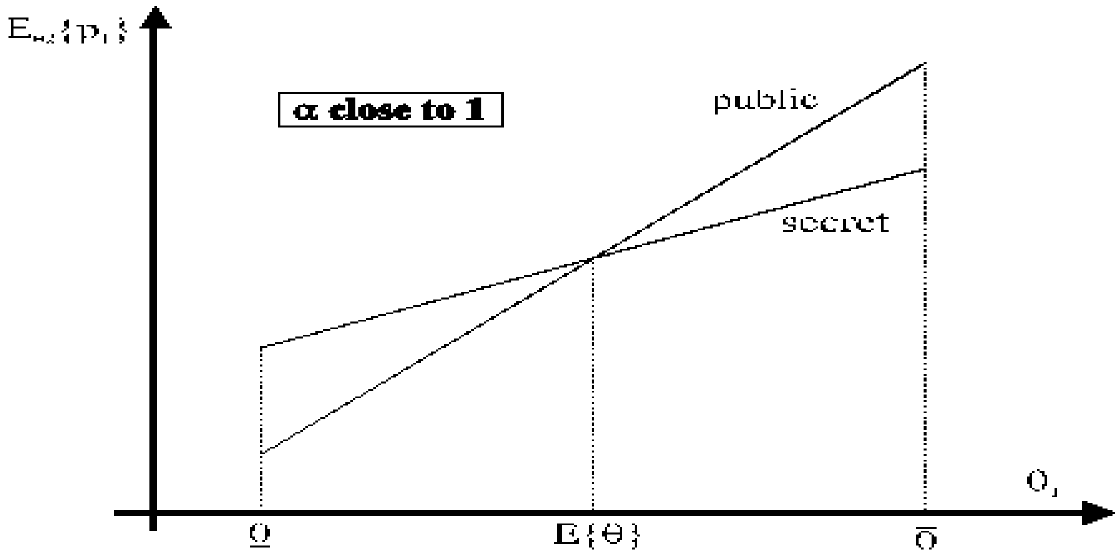


Figure 4: Prices with independent costs, α close to 1



We see on the figures that *public disclosure of contracts doesn't affect the expected price, but the slope of the price function. The price is less responsive to costs if α is small*, i.e. when states care mostly about consumer surplus. Indeed, the price is more responsive to costs if:

$$-\frac{\partial q_i^{PI}}{\partial \theta_i} > -2\frac{\partial q_i^{SI}}{\partial \theta_i}.$$

Because signalling induces a reaction from the rival that limits the impact on the price, the price is more responsive to costs under public contracts than under secret contracts only if the strategic signalling/commitment effects are strong enough to more than double the responsiveness of one firm's production to its cost. This occurs when incentive costs are low and therefore when α is large. When α is small, informational asymmetries between the state agency and the regulated firm limit the signalling/commitment effects and the slope of the price function is reduced compared to the case where there is no signalling.

The effect of price on gross ex-ante consumers' surplus is thus ambiguous (and is negative for α small). In any case however, the benefits from the reduction of the informational rents and of the productive inefficiencies dominate, and direct (but tedious) computation shows that:

$$EW^{PI} - EW^{SI} = \frac{-9 + 22B^* - (B^*)^2 + 20\alpha - 10B^*\alpha - 8\alpha^2}{108} > 0.$$

Consequently, we have:

Proposition 6 *If costs are independent, welfare is higher with public contracts than with secret contracts.*

4.3 Perfect correlation of costs

4.3.1 Secret regulation

If contracts are secret, as in the previous case, an equilibrium will be characterized by two production profiles, $q_i(\theta)$ and $q_j(\theta)$, where θ is the common cost factor. We prove in the appendix the following lemma:

Lemma 3 *Under imperfect information and perfectly correlated costs, when regulation contracts are secret, the symmetric linear equilibrium is characterized by the following unitary subsidy, equilibrium production and price:*

$$s^{SP}(\theta) = \frac{a-\theta}{2} - \frac{3}{2}\left(\frac{1-\alpha}{3-\alpha}\right)(\theta - \underline{\theta}),$$

$$q^{SP}(\theta) = a - \theta - \frac{1-\alpha}{3-\alpha}(\theta - \underline{\theta}),$$

$$p^{SP}(\theta) = \theta + \frac{1-\alpha}{3-\alpha}(\theta - \underline{\theta}).$$

Proof. See appendix. ■

The most interesting effect concerns the informational rent. The FOC for the revelation constraint can be written as:

$$\frac{d\Pi_i(\theta)}{d\theta} = -\left(1 + \frac{\partial q_j(\theta)}{2\partial\theta}\right) q_i(\theta)$$

and since $\frac{\partial q_j(\theta)}{\partial\theta} < 0$, the slope of the informational rent is lower than without a competitor, under closed economies. One can check that, in equilibrium, the slope of this rent is:

$$\frac{d\Pi^{SP}(\theta)}{d\theta} = -\frac{1}{(3-\alpha)} q^{SP}(\theta).$$

For the same production, this is obviously lower (in absolute value) than the slope under protected markets: $-q_i(\theta)$. *International competition relaxes the incentive constraints.*

When the domestic firm with cost θ overstates its cost at $\tilde{\theta}$, it faces a more efficient competitor than if the true cost where $\tilde{\theta}$ and therefore a smaller anticipated residual demand.[13] This effect, that we call the *correlation effect* reduces, ceteris paribus, the gain from such a deviation (compared to the fixed residual demand case, which applies to the closed economy). The result is that the informational rent necessary to prevent misreports for a given profile of production is reduced. This effect is in line with the results of Brainard and Martimort (1995).

[13]The rival firm's production is $q_j(\theta) > q_j(\widetilde{\theta})$.

The marginal national incentive to increase quantity starting from equal productions is the same as in the case of a closed economy (equal to $p - \theta$) while incentive costs are reduced. Therefore the standard rent/efficiency trade-off tips more in favor of efficiency: states induce a smaller reduction in production compared to the ex-post efficient benchmark level.

Given that the price is closer to efficiency and rents are reduced, it is then immediate that welfare increases:

Proposition 7 *Under imperfect information, secret contracts and perfect cost correlation, the creation of a common market is welfare improving. It reduces the informational rent $\Pi_i(\theta)$ of the regulated firms, reduces the price level and increases productions.*

4.3.2 Public regulation with perfect costs correlation

Let us now consider the case of public contracts and see how precommitment effects change the results. This situation involves no signalling since costs are perfectly correlated. But states may still use contracts as a strategic device. Using linear rules is no longer equivalent to quantity regulation and one has to solve the model as a two-stage game.

During the first stage, both governments propose a menu of contracts: $(s_i(.), t_i(.))$. Firm i chooses $\left(s_i(\tilde{\theta}_i), t_i(\tilde{\theta}_i)\right)$ within this menu, by announcing $\tilde{\theta}_i$. In the second stage, firms compete in quantities in the common market, after having observed the subsidy policies chosen by their competitor.

The Cournot equilibrium in the last stage after the choice of subsidy coefficients (s_1, s_2) yields Cournot quantities $q_i(\theta, s_i, s_j)$. It is then possible to characterize the equilibrium choice of subsidy policies in the first stage.

Lemma 4 *Under imperfect information, public regulation contracts and with perfect cost correlation, the symmetric linear equilibrium corresponds to the following unitary subsidy, production and price:*

$$s^{PP}(\theta) = \frac{a - \theta}{2} - \frac{1 - \alpha}{2(2 - \alpha)}(\theta - \underline{\theta}),$$

$$q^{PP}(\theta) = a - \theta - \frac{1 - \alpha}{3(2 - \alpha)}(\theta - \underline{\theta}),$$

$$p^{PP}(\theta) = \theta + \frac{1 - \alpha}{3(2 - \alpha)}(\theta - \underline{\theta}).$$

Proof. See appendix. ■

One can compare the situation with the secret contracts case using the equilibrium price. It is immediate to see that the price is reduced. Although the conclusion is similar to those of Brander and Spencer (1985) and Brainard and Martimort (1994), this result is quite different from these analyses of strategic trade policy. They focus on the interaction of firms on a third country market so that in these analyses only profit matters. In our model, states care about consumers' surplus. The result is that if one starts from the symmetric secret contract equilibrium, one state would not benefit from a change in the foreign firm's production: direct computation shows that here, the effect on consumers' surplus is exactly offset by the profit effect. This results from the fact that states internalize consumers' surplus; it is a mere generalization of the result obtained under perfect information and identical costs. This illustrates, first, that the strategic trade policy effects emphasized by Brander and Spencer are absent in our model, and second, that the only effects that may happen are related to a change in the slope of the subsidy profile.

This modification in the slope of the subsidy profile is due to the fact that *the public observability of contracts further relaxes the incentives constraints.* A firm is forced to disclose its chosen subsidy rate to its rival. Therefore, misreporting the true value of the cost so as to change the subsidy rates also affects the rival's behavior. This is internalized by the firm when choosing within the menu. In particular, overstating the cost reduces the subsidy rate and therefore raises the rival's production, making such a deviation less attractive for the firm. Indeed, the slope of the informational rent in the public contracts case is negative, equal to:

$$\begin{aligned}\frac{d\Pi_i(\theta)}{d\theta} &= -\tfrac{2}{3}q_i(\theta, s_i(\theta), s_j(\theta))\left(1 + \frac{\partial s_j(\theta)}{\partial \theta}\right) \\ &> -\tfrac{2}{3}q_i(\theta, s_i(\theta), s_j(\theta))\left(1 + \frac{\partial s_j(\theta)}{2\partial \theta}\right)\end{aligned}$$

and therefore less steep than the slope of the rent under secret contracts.

We shall refer to this effect as the *incentive effect of public messages* (message here stands for the announcement of the choice within the menu): this effect does not rely on the public observability of the global mechanism but on the public observability of the particular subsidy rate. It also relies on the fact that the opponent's firm has some discretion power after the revelation stage (stage at which the subsidy rate is chosen) which enables it to react to the announcement of the choice. Incentive constraints being relaxed, states induce larger production levels than in the secret contracts case.

The equilibrium slope of the informational rent is indeed given by:

$$\frac{d\Pi^{PP}(\theta)}{d\theta} = -\frac{1}{3(2-\alpha)} q^{PP}(\theta).$$

and given that $\frac{1+\alpha}{6-2\alpha} > \frac{1}{6-3\alpha}$, we can check that the rents are reduced compared to the secret contracts case. Given that both price and rents are reduced, it is obvious that welfare increases compared to the secret contracts case. To summarize:

Proposition 8 *$EW^{PP} > EW^{SP}$. For all $\theta > \underline{\theta}$, $p^{SP}(\theta) > p^{PP}(\theta)$ and $\Pi^{PP}(\theta) < \Pi^{SP}(\theta)$.*

These results are illustrated on the following figures.

Figure 5: Quantities with perfectly correlated costs

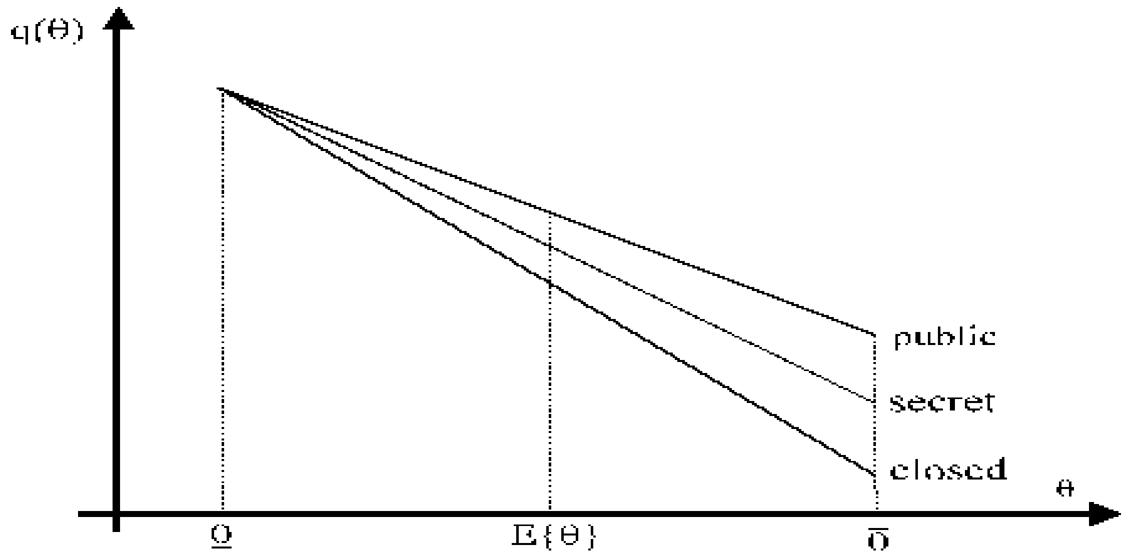
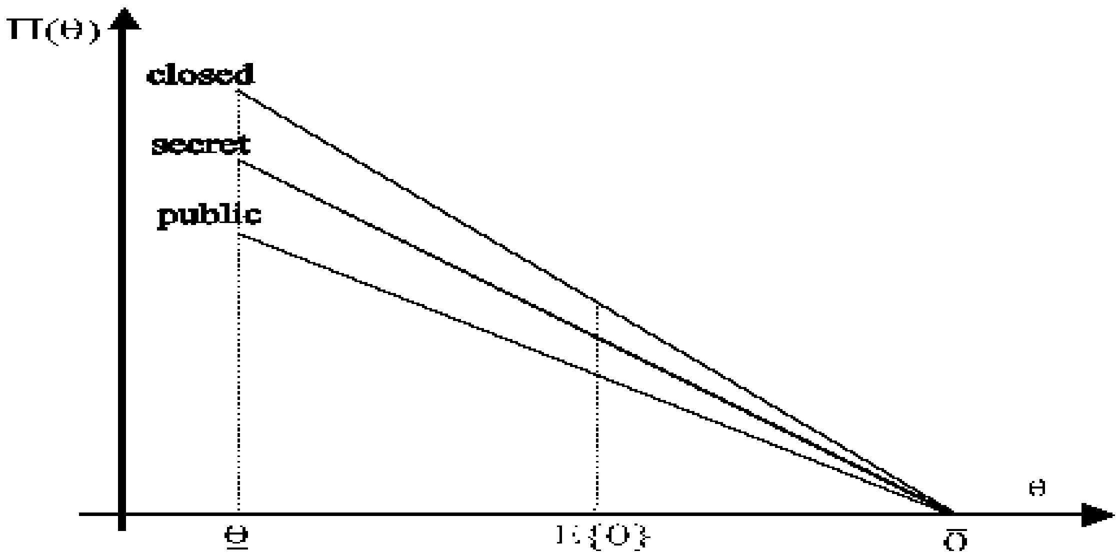


Figure 6: Informational rents with perfectly correlated costs



5 Segmented markets

In this section, we come back on the assumption of common market. Suppose that, when the two countries decide to open the frontiers, two segmented open markets appear, one in each country. Each firm can produce for both markets. We will only analyze the perfect information case. Let q_{ii} denote the quantity produced by the firm in country i for market i and q_{ij} the quantity exported by this firm in market j, *with a unitary "transportation cost"* c,[14] that is assumed to be small. Consumption in state i is:

$$q_{ij} + q_{ji} = q_i^d,$$

and the inverse demand function is:

$$p_i = a - \frac{q_{ii}}{\lambda_i} - \frac{q_{ji}}{\lambda_i}.$$

[14] c may also be seen as capacity cost incured by one firm when it decides to enter the other country.

5.1 Subsidizing total production

Suppose that only total production is verifiable, or that a joint agreement prevents the states from discriminating between domestic sales and exports. Then the allocation of production between domestic production and exports cannot be controlled by the government which must rely on a unitary subsidy s_i that applies to the total production of the firm (along with a lump-sum transfer).

Firms' total profit can then be rewritten as:

$$\Pi_i = (p_i - \theta_i + s_i)\, q_{ii} + (p_j - \theta_i - c + s_i)\, q_{ij} - t_i.$$

We denote:

$$\pi_i = (p_i - \theta_i)\, q_{ii} + (p_j - \theta_i - c)\, q_{ij}.$$

To understand the link between the common market case and the segmented market case, we shall prove the equivalence mentioned earlier. In any case (secret or public regulations), firms will play a Cournot competition game with perceived marginal costs $m_i = \theta_i - s_i$ and transportation cost c. One firm's perceived marginal cost is anticipated by the rival in the secret contract game, whereas it is observed in the public contract game. Our modeling assumptions then imply:

Lemma 5 *In the Cournot segmented market game, if firm i anticipates that firm j allocates the production across markets according to:*

$$q_{jj} = \frac{\lambda_j}{\Lambda} q_j + \frac{\lambda_1 \lambda_2}{\Lambda} c \qquad \text{and} \qquad q_{ji} = \frac{\lambda_i}{\Lambda} q_j - \frac{\lambda_1 \lambda_2}{\Lambda} c,$$

it is optimal for firm i to allocate its production according to:

$$q_{ii} = \frac{\lambda_i}{\Lambda} q_i + \frac{\lambda_1 \lambda_2}{\Lambda} c \qquad \text{and} \qquad q_{ij} = \frac{\lambda_j}{\Lambda} q_i - \frac{\lambda_1 \lambda_2}{\Lambda} c,$$

provided that all productions are positive.

Proof. See appendix. ■

It is also immediate to check that this allocation rule is satisfied in any Cournot equilibrium with constant marginal cost. One can then solve the segmented market equilibrium in the case of no regulation, secret regulation and public regulation using only total quantities q_1 and q_2, and imposing the above allocation rule. The production cost of firm i is then:

$$(\theta_i + \frac{\lambda_j}{\Lambda}c)q_i - \frac{\lambda_i\lambda_j}{\Lambda}c^2.$$

The price is the same in both markets, $p_i = a - \frac{q_1+q_2}{\Lambda}$, equal to the common market price. The consequence is that the reduced segmented markets game where only total quantities are considered is equivalent to a common market game with the modified marginal costs $\theta_i + \frac{\lambda_j}{\Lambda}c$. The results of section 2 still apply. In particular, the equilibrium price and quantities are:

$$p_i = \frac{1}{2}\left(c + \theta_i + \theta_j\right),$$

$$q_i^s = \lambda_i\left(a - \theta_i\right) + \frac{\lambda_j}{2}\left(\theta_j - \theta_i - c\right), \text{ when regulations are secret,}$$

$$q_i^p = q_i^s + \frac{\Lambda}{2}\left(\theta_j + \frac{\lambda_i}{\Lambda}c - \theta_i - \frac{\lambda_j}{\Lambda}c\right), \text{when regulations are public.}$$

Several comments are worth making. First *both firms export* despite the fact that at least for one of them (the highest cost firm) and sometimes for both, the market price is below the cost adjusted for transportation cost. The reason is that the subsidy bears on all the production so that the perceived marginal cost for the firms is below the true cost both for domestic production and export.

If the transportation cost is high, the prices increase in both countries and productions decrease when markets are opened, which is at odd with standard results (with perfect competition there would be no trade). This phenomenon relies on the imperfect nature of regulation: state cannot separate export from domestic production. *Opening the markets reduces the regulatory power of the state, by allowing the firm to use the subsidy to reduce the cost of its foreign activities.* Prices are too high and the export margin is negative for both countries. No government wishes to reduce the prices further because this would raise its export level and increase export losses.

Looking at the trade balance for the secret contract case:

$$q_{12} - q_{21} = \frac{\Lambda}{2}\left(\theta_j + \frac{\lambda_i}{\Lambda}c - \theta_i - \frac{\lambda_j}{\Lambda}c\right).$$

One obtains the following result:

Proposition 9 *The trade balance of country 1 may be negative despite its cost advantage. This occurs when the market size of country 1 is small compared to country 2.*

This may seem counterintuitive but follows from the cost and benefit of regulation mentioned above. If country 2 is large, its government tends to subsidize the firm heavily because the consumers' surplus is large while exports are perceived as relatively less important. On the contrary, the government in state 1 cares more about export profits which represent a large share of national surplus and will therefore tend to limit subsidies so as to reduce the distortion compared to profit maximization. Although the true production cost is lower in state 1, the perceived cost may be lower for the firm in state 2. When the cost differential is small, the result is that country 2 exports more.[15]

Let us now consider welfare. Given that the reduced cost function is the same for all types of regulations, the comparison between public and secret regulation is unchanged so that *public regulation Pareto dominates secret regulation.*

The comparison between the closed economy and the open economy is more ambiguous. Since regulation cannot control for the allocation of production between markets, opening the markets induces inefficient trade and excessive transportation costs. If we denote by $W_i^s(\theta_i, \theta_j)$ the welfare for the common market (under secret contract), the change in welfare when markets are open is:

$$W_i^s(\theta_i + \frac{\lambda_j}{\Lambda}c, \theta_j + \frac{\lambda_i}{\Lambda}c) - W_i^s(\theta_i, \theta_j) - \frac{\lambda_1\lambda_2}{\Lambda}c^2 + \frac{\lambda_i + 2\lambda_j}{8}(\theta_1 - \theta_2)^2.$$

We thus obtain:

Proposition 10 *Opening the markets to competition is welfare improving only if the cost differential is large compared to the transportation cost.*

As we can see, international competition may be detrimental when regulators are not able to separate the total cost of the firm between exports and domestic production. This suggests that efficiency may increase if they are able to do so. We examine this in the next section.

[15] This result contrasts with the case of imperfect competition without regulation, where the country with the smallest market size has a positive trade balance when costs are similar (see Markusen (1981)).

5.2 Subsidizing export vs domestic production

Assume now that the regulatory agencies can separate domestic production from exports and thus design differentiated subsidy rates for both activities: s_{ii} is a marginal subsidy on domestic production while s_{ij} is a marginal export subsidy, t_i is still a lump sum tax on profits. The two markets are then separated (under perfect information). Countries plays two games: one on market 1 and one on market 2. The game in market i can be solved as a segmented market game readjusting the market sizes: the market size of country i is still λ_i, but the market size of country j is now 0. It is then immediate to obtain:

Lemma 6 *With segmented markets and differentiated subsidy rates:*

- *if* $\theta_j + c \geq \theta_i$, *firm* j *does not export to country* i *and* $p_i = \theta_i$,
- *if* $\theta_j + c < \theta_i$, *then* $p_i = \frac{1}{2}(\theta_i + \theta_j + c)$ *and:*
  $q_{ii} = \lambda_i(a - \theta_i)$, $q_{ji} = \frac{\lambda_i}{2}(\theta_i - \theta_j - c)$ *with secret regulations,*
  $q_{ii} = \lambda_i(a - \theta_i) - \frac{\lambda_i}{2}(\theta_i - \theta_j - c)$, $q_{ji} = \lambda_i(\theta_i - \theta_j - c)$ *with public regulations.*

Now the conclusions are quite straightforward. *Opening the markets is always welfare improving, and precommitment effects are beneficial for both states. One state benefits from lower prices, while the other benefits from export revenues.* The main result that we want to emphasize here is:

Proposition 11 *With segmented markets, if one state regulates its domestic firm, it is optimal to allow export subsidies in the other state.*

6 Conclusion

This work has analyzed the effect of bilateral trade in concentrated industries where firms are regulated at the national level. Our model emphasizes the effects of trade on consumers' surplus and firms' informational rents. For the common market case, we showed that this may improve efficiency on two grounds: first it improves the allocative efficiency, second it reduces the agency costs of regulation.

The positive effects of trade extend to the segmented markets case when states can separate domestic production and exportation in the design of regulation, and in this case it is optimal to allow states to use export subsidies. When regulation is imperfect and firms can falsify accounting information, in the segmented markets case, there is too much trade because state subsidies designed to reduce domestic prices will also reduce exportation costs.

Our model calls for a clear accounting separation between domestic and foreign activities. Regulation should be designed in such a way that it allows a clear distinction between markets.

We have focused on quantity regulation, but the analysis suggests that things may be quite different with price cap regulation since prices are designed for specific markets. The same type of accounting falsification problems may however arise if the regulation is based on average revenue instead of effective prices as it is often the case. Price cap regulation as well as price competition should be the object of further studies.

We have also assumed that regulations were based on a menu of linear contracts. For the secret contracts case, this is innocuous but it is not when one comes to precommitment effects. For example, it is easy to show that if states use public quantity regulations (menus of quantities and transfers with public messages), public disclosure of contracts has no effect (since one state cannot affect the rival production). Most of the works on precommitment effects assume that the principal (the state agency here) designs a single public nonlinear transfer (see for the most relevant part Brainard and Martimort (1995), but also Kuhn (1989), Maggi (1992)). Although this may seem attractive because this saves on messages, we conjecture that in our context state agencies should prefer to rely on menus with disclosure of the contract chosen within the menu. The reason is that by doing so one can save on agency costs. With a menu of linear contracts, when a firm overstates its cost, it induces a reaction of the rival firm (which increases its production) that reduces the attractiveness of lying, which is not the case under a single nonlinear transfer rule. Choosing linear contracts within the menu is then attractive because it is robust to noisy observability of productions. Menus, however, may create renegotiation problems (see Caillaud and al. (1995) for an analysis of precommitment effects under imperfect information and secret renegotiation of contracts) and further work should be devoted to the analysis of this issue.

References

[1] Baron D. and R. Myerson (1982): "Regulating a Monopolist with Unknown Costs", *Econometrica,* 50, pp 911-930.

[2] Ben-Zvi S. and E. Helpman (1992): "Oligopoly in Segmented Markets", in *Imperfect Competition and International Trade,* G. Grossman ed., Cambridge: MIT Press.

[3] Brainard L. and D. Martimort (1995): "Strategic Trade Policy with Incompletely Informed Policy Makers", *Review of Economic Studies,* Vol 63(1), pp 81-106.

[4] Brainard L. and D. Martimort (1995): "Strategic Trade Policy Design with Asymmetric Information and Public Contracts", mimeo, MIT.

[5] Brander, J. and P. Krugman (1983): "A "Reciprocal Dumping" Model of International Trade", *Journal of International Economics* 15, pp 313-323.

[6] Brander, J. and B. Spencer (1985): "Export Subsidies and International Market Share Rivalry", *International Journal of Economics,* 18, pp 83-100.

[7] Caillaud B., Jullien B. and P. Picard (1995), "Competing Vertical Structures: Precommitment and Renegotiation", *Econometrica,* Vol 63(3), pp 621-646.

[8] Collie D. and M. Hviid (1992): "Export Subsidies as Signal of Competitiveness", *Scandinavian Journal of Economics,* 95, pp 327-339.

[9] Corden W. (1974): *Trade Policy and Economic Welfare,* Oxford: Clarendon Press.

[10] Eaton, J. and G.M. Grossman (1986): "Optimal trade and industrial policy under oligopoly", *Quarterly Journal of Economics*, 101, pp 383-406.

[11] European Community (1991): "Fair Competition in the Internal Market: Community State Aid Policy", *European Economy 48.*

[12] *European Union: Selected Instruments taken from the Treaties.*

[13] Helpman E. and P. Krugman (1989): *Trade Policy and Market Structure,* Cambridge: MIT Press.

[14] Krugman P. and M. Obstfeld (1988): *International Economics: Theory and Policy,* Chicago: Scott Foresman.

[15] Kuhn K.U. (1989): "Vertical Restraints in a Manufacturer Duopoly: The Case of Nonlinear Pricing", Mimeo Nuffield College, Oxford.

[16] Laffont J.J. and J. Tirole (1993): *A Theory of Incentives in Regulation and Procurement,* Cambridge: MIT Press.

[17] Maggi G. (1992): "Strategic Trade Policy under Asymmetric Information", mimeo, Stanford.

[18] Markusen J. (1981): "Trade and the Gains from Trade", *Journal of International Economics* 11, pp 531-551.

[19] Qiu L (1992): "Optimal Strategic Trade Policy under Asymmetric Information", *Journal of International Economics,* 21, pp 393-423.

A Appendix

A.1 Proof of Lemma 1

The government's welfare can be written as:

$$E\{\frac{1}{2}(\frac{q_i(\theta)+q_j(\theta)}{2})^2+\left(a-\frac{q_i(\theta)+q_j(\theta)}{2}-\theta-(1-\alpha)(\theta-\underline{\theta})\right)q_i(\theta)\}.$$

Optimizing social objectives subject to the FOC of the revelation constraint yields $q_i(.)$ as a best response to q_j^e:

$$2(a-\theta)-2(1-\alpha)(\theta-\underline{\theta})-\frac{3}{2}q_i(\theta)-\frac{1}{2}q_j^e=0.$$

Taking expectation with respect to θ and using symmetry, we can determine the equilibrium expected quantity by the following equation:

$$E\{q(\theta)\}=a-E\{\theta\}-(1-\alpha)(E\{\theta\}-\underline{\theta}).$$

The equilibrium quantity profile can now be recovered:

$$q^{SI}(\theta)=a-\theta-\frac{5-4\alpha}{3}(\theta-E\{\theta\})-(1-\alpha)(E\{\theta\}-\underline{\theta}).$$

The price then depends on both costs parameter and is given by:

$$p^{SI}(\theta_1,\theta_2)=\frac{\theta_1+\theta_2}{2}+\frac{5-4\alpha}{3}(\frac{\theta_1+\theta_2}{2}-E\{\theta\})+(1-\alpha)(E\{\theta\}-\underline{\theta}).$$

It is easy to see that $p^{SI}(\theta_1,\theta_2)-\frac{\theta_1+\theta_2}{2}$ is an increasing function of $\frac{\theta_1+\theta_2}{2}$, that is negative at $\underline{\theta}$ and positive at $E\{\theta\}$. The final part of the Lemma follows ■

A.2 Proof of Proposition 5

Expected national social welfare in state 1 is equal to:

$$EW^{SI}=E\{\frac{1}{2}(a-p^{SI}(\theta_1,\theta_2))^2+(p^{SI}(\theta_1,\theta_2)-p^A(\theta_1))q^{SI}(\theta_1).$$

which can be written as:

$$EW^{SI} - EW^{A} = E\{\frac{1}{2}(p^{SI}(\theta_1, \theta_2) - p^{A}(\theta_1))^2 + (q^{SI}(\theta_1) - q^{A}(\theta_1))^2\}.$$

Hence, the opening of a common market is welfare improving. Finally, note that the rent in autarchy is $\int_{x>\theta} q^A(x)dx$. With a common market, it becomes:

$$\int_{x>\theta}(q^A(x) - \frac{2-\alpha}{3}(x - E\{\theta\}))dx = \int_{x>\theta} q^A(x)dx - \frac{2-\alpha}{6}(\underline{\theta} + 1 - \theta)(\theta - \underline{\theta}).$$

Hence the conclusion. ■

A.3 Proof of Lemma 2

For given beliefs Σ, the equilibrium production for firm i must be a best response to the equilibrium production of firm j, given the pair of observed unitary subsidy (s_i, s_j). It follows:

$$q_i^{\Sigma}(\theta_i; s_i, s_j) = a - \theta_i + s_i - \frac{1}{2} q_j^{\Sigma}(\sigma_j(s_j); s_i, s_j).$$

It is then straightforward to derive the equilibrium quantities in the subgame following (s_i, s_j) and under the previously mentioned beliefs. One finds that the production of a firm with cost θ_i choosing subsidy s_i is:

$$q_i^{\Sigma}(\theta_i; s_i, s_j) = \frac{1}{3}\left(2a - 3\theta_i + 4s_i - \sigma_i(s_i) + 2\sigma_j(s_j) - 2s_j\right).$$

The price that prevails ex-post is a function of both cost parameters and subsidy coefficients:

$$\begin{aligned} p^{\Sigma}(\theta_i, \theta_j, s_i, s_j) &= a - \frac{1}{2}\left(q_i^{\Sigma}(\theta_i; s_i, s_j) + q_j^{\Sigma}(\theta_j; s_i, s_j)\right) \\ &= \frac{1}{6}\left(2a + 3\theta_i + 3\theta_j - 2s_i - 2s_j - \sigma_i(s_i) - \sigma_j(s_j)\right). \end{aligned}$$

From these, it is now possible to compute firm i's utility when its cost is θ_i, when it faces a subsidy policy $(t_i(.), s_i(.))$ possibly different from the equilibrium policy, and when it conjectures however that firm j faces the equilibrium policy and draws inference about s_i using the equilibrium function $\sigma_i(.)$:

$$\Pi_i(\tilde{\theta}_i, \theta_i) = \mathbf{E}_{\theta_j}\left[-t_i(\tilde{\theta}_i) + \frac{\left(2a - 3\theta_i + 4s_i(\tilde{\theta}_i) - \sigma_i(s_i(\tilde{\theta}_i)) + 2\theta_j - 2s_j^*(\theta_j)\right)^2}{18}\right],$$

which implies the following first-order incentive constraints:

$$\frac{d\Pi_i}{d\theta_i} = -\mathbf{E}_{\theta_j}\left[q_i^{\Sigma}(\theta_i, s_i(\theta_i), s_j^*(\theta_j))\right].$$

Moreover, a sufficient second order incentive constraint is that:

$$\frac{4 - \dot{\sigma}(s_i(\theta_i))}{3}\dot{s}_i(\theta_i) \leq 0.$$

Given the opponent's behavior and conjectures, the optimal subsidy policy in country i can be obtained by maximizing, subject to the first-order incentive constraint, the expected value, with expectation taken over θ_i and θ_j, of the objective function:

$$\begin{aligned}&\frac{1}{2}\left(a - p^{\Sigma}(\theta_i, \theta_j, s_i(\theta_i), s_j^*(\theta_j))\right)^2 \\ &\quad + \left(p^{\Sigma}(\theta_i, \theta_j, s_i(\theta_i), s_j^*(\theta_j)) - \theta_i - (1-\alpha)(\theta_i - \underline{\theta})\right) q_i^{\Sigma}(\theta_i, s_i(\theta_i), s_j^*(\theta_j)).\end{aligned}$$

Optimizing pointwise with respect to $s_i(.)$ yields the following first order condition:

$$\begin{aligned}\mathbf{E}_{\theta_j}\Bigg[&\left(a - p^{\Sigma}(\theta_i, \theta_j, s_i^*(\theta_i), s_j^*(\theta_j)) - q_i^{\Sigma}(\theta_i, s_i^*(\theta_i), s_j^*(\theta_j))\right)\frac{2 + \dot{\sigma}_i(s_i^*(\theta_i))}{6} \\ &+ \left(p^{\Sigma}(\theta_i, \theta_j, s_i^*(\theta_i), s_j^*(\theta_j)) - \theta_i - (1-\alpha)(\theta_i - \underline{\theta})\right)\frac{4 - \dot{\sigma}_i(s_i^*(\theta_i))}{3}\Bigg] = 0.\end{aligned}$$

In equilibrium, the first order conditions must be satisfied and beliefs must be correct or, more precisely, using the notation $s^e \equiv \mathbf{E}_{\theta_j}\left[s_j^*(\theta_j)\right]$ and dropping the i indices,

$$\begin{aligned}0 = {}& 3\left[2\dot{s}^*(\theta) + 1\right]\left[\theta - \underline{\theta} - \tfrac{1}{2} - s^*(\theta) + s^e\right] \\ &+ 2\left[4\dot{s}^*(\theta) - 1\right]\left[a - \underline{\theta} + \tfrac{1}{2} - (5 - 3\alpha)(\theta - \underline{\theta}) - s^*(\theta) - s^e\right].\end{aligned}$$

Using this, the symmetric separating equilibrium involves:

$$s^{PI}(\theta) = \frac{a-\theta}{2} - \frac{2B^*-1}{2}(\theta - E\{\theta\}) - \frac{3}{2}(1-\alpha)(E\{\theta\} - \underline{\theta}),$$

where B^* is the positive solution of equation: $14x^2-(35-24\alpha)x-13+6\alpha = 0$. It can be easily verified that the second-order sufficient incentive constraint is satisfied for this value.

The corresponding equilibrium production and price follow. ■

A.4 Proof of Lemma 3

Given the quantity profile $q_j(.)$, consider a regulation policy $(t_i(.), q_i(.))$: the utility of firm i from pretending it has cost $\tilde{\theta}$ when its cost is θ, assuming that firm j reveals its information, is given by:

$$\Pi_i(\tilde{\theta}, \theta) = -t_i(\tilde{\theta}) + q_i(\tilde{\theta}) \left[a - \theta - \frac{q_i(\tilde{\theta}) + q_j(\theta)}{2} \right],$$

which is equivalent to the following conditions:

$$\frac{d\Pi_i(\theta)}{d\theta} = -\left(1 + \frac{\partial q_j(\theta)}{2\partial\theta}\right) q_i(\theta) \text{ and } \left(1 + \frac{\dot{q}_j(\theta)}{2}\right) \dot{q}_i(\theta) \leq 0.$$

The governments' welfare can then be written as:

$$E\{\frac{1}{2}(\frac{q_i(\theta_i) + q_j(\theta_j)}{2})^2 + (a - \frac{q_i(\theta_i) + q_j(\theta_j)}{2} - \theta_i) q_i(\theta_i) \\ -(1-\alpha) q_i(\theta_i) \left(1 + \frac{\partial q_j(\theta)}{2\partial\theta}\right) (\theta - \underline{\theta})\}.$$

Optimizing the social objectives subject to the incentive constraints determines the profile $q_i(.)$ as a best response to the competitor's production profile $q_j(.)$:

$$2(a-\theta) - 2(1-\alpha)(\theta - \underline{\theta}) - \frac{3}{2} q_i(\theta) - \frac{1}{2} q_j(\theta) - (1-\alpha)(\theta - \underline{\theta}) \frac{\partial q_j(\theta)}{\partial\theta} = 0.$$

This yields a differential equation for the symmetric equilibrium:

$$2(a-\theta) - 2(1-\alpha)(\theta - \underline{\theta}) - 2q(\theta) - (1-\alpha)(\theta - \underline{\theta})\dot{q}(\theta) = 0,$$

with linear solution given by:

$$q^{SP}(\theta) = a - \theta - \frac{1-\alpha}{3-\alpha}(\theta - \underline{\theta}).$$

Hence the equilibrium price of the Lemma. One can finally recover the linear subsidy term by noticing that:

$$\begin{aligned} q_i(\theta, \tilde{\theta}) &= \arg\max_q \left\{ -t(\tilde{\theta}) + \left(a - \tfrac{q + q_j(\theta)}{2} - \theta + s_i(\tilde{\theta}) \right) q \right\} \\ &= a - \theta + s_i(\tilde{\theta}) - \tfrac{q_j(\theta)}{2}, \end{aligned}$$

and the optimal subsidy is therefore:

$$s^{SP}(\theta) = \frac{a-\theta}{2} - \frac{3}{2}(\frac{1-\alpha}{3-\alpha})(\theta - \underline{\theta}).$$

■

A.5 Proof of Lemma 4

Following the choice of unitary subsidies (s_i, s_j), the Cournot continuation equilibrium is characterized by:

$$\begin{aligned} q_i(\theta, s_i, s_j) &= \frac{2}{3}(a - \theta + 2s_i - s_j) \\ p(\theta, s_1, s_2) &= \frac{1}{3}(a + 2\theta - s_1 - s_2) \\ \Pi_i(\theta, s_i, s_j) &= \frac{1}{2} q_i(\theta, s_i, s_j)^2 - t_i \end{aligned}$$

Following a now standard route, the FOC for the revelation constraint of firm i, assuming that the other firm announces the truth, reduces to:

$$\frac{d\Pi_i(\theta)}{d\theta} = -\frac{2}{3} q_i(\theta, s_i(\theta), s_j(\theta)) \left(1 + \frac{\partial s_j(\theta)}{\partial \theta} \right).$$

The following second order condition has also to be satisfied:

$$\frac{\partial s_i(\theta)}{\partial \theta} \left(1 + \frac{\partial s_j(\theta)}{\partial \theta} \right) \leq 0.$$

If the slope of the subsidy is between -1 and 0, the rent is positive for all types when $\Pi_i\left(\underline{\theta}+1\right) \geq 0$. We focus on the unique symmetric equilibria.[16] For this equilibrium, we can ignore the second order incentive constraint and set $\Pi_i\left(\underline{\theta}+1\right) = 0$. One can then verify ex-post that all the constraints are verified.

The governments' welfare can then be written as:

$$E\{\frac{1}{2}(a-p(\theta,s_i(\theta),s_j(\theta))^2+(p(\theta,s_i(\theta),s_j(\theta))-\theta)q_i(\theta,s_i(\theta),s_j(\theta))$$
$$-(1-\alpha)\frac{2}{3}q_i(\theta,s_i(\theta),s_j(\theta))\left(1+\frac{\partial s_j(\theta)}{\partial\theta}\right)(\theta-\underline{\theta})\}.$$

The FOC of the optimization problem are:

$$4a-\theta-7s_i(\theta)-s_j(\theta)-8(1-\alpha)(\theta-\underline{\theta})(1+\frac{\partial s_j(\theta)}{\partial\theta})=0.$$

The symmetric equilibrium is given by:

$$s^{PP}(\theta)=\frac{a-\theta}{2}-\frac{1-\alpha}{2(2-\alpha)}(\theta-\underline{\theta}),$$

which induces the quantity and price mentioned in the Lemma. ■

A.6 Proof of Lemma 5

Suppose that firm i anticipates productions q_{jj} and q_{ji}. For a fixed production q_i, it will allocates the production across market by solving:

$$\begin{array}{l} \underset{(q_{ii},q_{ij})}{Max}\ (p_i-\theta_i)\,q_{ii}+(p_j-\theta_i-c)\,q_{ij}-t_i \\ \text{subject to } q_i=q_{ii}+q_{ij}, \end{array}$$

and with:

$$p_i=a-\frac{q_{ii}}{\lambda_i}-\frac{q_{ji}}{\lambda_i}.$$

This leads to:

$$\begin{cases} q_{ii}=\frac{\lambda_i}{2(\lambda_i+\lambda_j)}\left(2q_i-\frac{\lambda_j}{\lambda_i}q_{ji}+q_{jj}+\lambda_j c\right) \\ q_{ij}=\frac{\lambda_j}{2(\lambda_i+\lambda_j)}\left(2q_i+q_{ji}-\frac{\lambda_i}{\lambda_j}q_{jj}-\lambda_i c\right). \end{cases}$$

The lemma then follows directly.

■

[16] Whether there also exist asymmetric equilibria eventually involving some bunching is an open question.