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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. They also extend under perfect information to an arbitrary number of states and regulated firms, to the existence of private importing firms and of a not too large export market.

Régulation des entreprises dans un marché commun

RÉSUMÉ. – Cet article étudie les effets de l'ouverture au commerce bilatéral en concurrence à la Cournot d'un secteur monopolistique dans lequel les entreprises sont régulées par des États maximisant le bien-être social. Les coûts des entreprises et les tailles des marchés peuvent différer selon les pays et l'information peut être asymétrique entre les agences de régulation et les entreprises. Les contrats de régulation sont ou non observés par le pays concurrent.

Nous montrons qu'il est optimal d'autoriser les deux États à réguler chacun leur entreprise : le commerce bilatéral améliore l'efficacité productive et réduit les coûts d'agence. Les effets des politiques commerciales stratégiques apparaissant lorsque les contrats sont publics bénéficient aux deux pays et réduisent aussi bien les inefficacités productives que les coûts d'agence. Nos résultats s'étendent en information parfaite au cas où les marchés sont segmentés lorsque les États peuvent utiliser à la fois des subventions aux exportations et à la production domestique, ainsi qu' à un nombre arbitraire d'États et de firmes régulées, à l'existence de firmes privées et d'un marché d'exportation de faible taille.

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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]. Moreover, because of asymmetric information between regulators and firms, regulation is also imperfect: it induces costs that are significative, in particular compared to the gains from free trade [4].

The role of national subsidy policies in a common market under imperfect competition and information thus remains a sensitive topic that we address

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.
4. Empirically, the gains from unilateral trade policy or the losses from bilateral state intervention are significative but small (see e.g. FEENSTRA [1988]), whereas WOLAK [1995] shows that information costs are also significative. BALLARD *et al.* [1985] and HAUSMAN and POTERBA [1987] estimate the cost of transferring public funds around 30%.

here. By designing subsidy policies, states pursue two types of objectives: they try to correct allocative distortions due to imperfect competition (i.e. monopoly) but they also affect the competitive advantage of their own firms in international markets. Our paper considers this twofold dimension of subsidy policies and tries to assess their welfare performances. 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 ourselves 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 and, in this case, marginal costs are perfectly correlated. 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 related to the reallocation of production across states.
- Trade reduces the agency costs of regulation, through a correlation effect related to the introduction of competition.
- Strategic trade policy effects that appear when subsidy rates are public reduce 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 further reduce 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 [5]. 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

5. 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.

of segmented markets with transportation costs, the results also hold when policy makers can isolate exports in total production. However, if they are unable to 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 [6]. Bilateral trade may then reduce social welfare.

Agency costs appear when production costs are private information of firms. To focus on the specific role of private information, we rule out the allocative effects explained above which are due to efficiency differences by assuming perfect correlation between marginal costs. Agency costs 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. Assuming that firms' 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.

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 MARTIMORT [1996 and 1997], 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 that the ultimate choice of contract is observed [7]. 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 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

6. 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.

7. This assumption is not innocuous and is discussed in the conclusion.

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 with transportation costs, to an arbitrary number of states and firms and to the existence of export markets. 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:

$$d_i(p) = \lambda_i(a - p).$$

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

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

as a function of price, or as $S_i(d_i)$ as a function of d_i, the 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 denote national production. The firm's net profit is given by:

$$\Pi_i = (p - \theta_i + s_i)q_i - t_i.$$

We also let $\pi_i = (p - \theta_i)q_i$ 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:

$$\begin{aligned} W_i &= S_i - s_i q_i + t_i + \alpha \Pi_i \\ &= S_i + \pi_i - (1 - \alpha)\Pi_i, \end{aligned}$$

where $\alpha \leq 1$.

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 θ_i, and the firm's profit is equal to the reservation level that we normalize to 0. Setting a subsidy rate such that $s_i = a - \theta_i$, the profit maximizing firm is induced to choose a production:

$$q_i = \arg\max_q \left\{ \left(a - \frac{q}{\lambda_i} - \theta_i + a - \theta_i \right) q \right\} = \lambda_i (a - \theta_i).$$

It is then easy 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 [8] market with total demand equal to $(\lambda_1 + \lambda_2)(a - p)$. We use the notation $\Lambda = \lambda_1 + \lambda_2$. So the inverse demand is:

$$p = a - \frac{Q}{\Lambda},$$

where Q stands for aggregate demand or supply on the common market.

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 [9]. 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.
- Regulation schemes are publicly observed once they are signed, before production decisions.

8. We study the segmented market case in section 5.
9. 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.

3 Open Market with Perfect Information

We first suppose that the costs of national firms are common knowledge to all regulatory agencies and firms. In the situation of bilateral trade under imperfect competition, we analyze the effects of a common market structure in the three scenarios mentioned above: in the absence of regulation, under secret regulation and under public regulation.

3.1. No Regulation

In the absence of regulation, the situation corresponds to a simple game of Cournot competition on the common market between the national firms. It is immediate to find the resulting equilibrium price $p = \frac{1}{3}(a + \theta_i + \theta_j)$. Note moreover that in this situation firms make positive Cournot profits.

3.2. Secret Regulation

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 direct choice of a production q_i and of a lump sum transfer, because there is a one-to-one relationship between quantity and subsidy rate *given fixed beliefs about the rival's production*. More precisely, any equilibrium outcome $(s_1, s_2, t_1, t_2, q_1(.), q_2(.))$ of the game where governments choose secret subsidy policies and firms then choose quantities as a function of their own subsidy rates, is payoff-equivalent to an equilibrium outcome of the game where governments directly choose quantities (q_1, q_2) and transfers (t_1, t_2), with $q_i = q_i(s_i) = \frac{\Lambda}{2}\left(a - \theta_i + s_i - \frac{q_j(s_j)}{\Lambda}\right)$, and conversely, by fixing subsidy rates $s_i = \theta_i - a + \frac{2q_i + q_j}{\Lambda}$. We can thus solve our original game as a one-stage game in which governments choose productions and tax all the profits above the reservation level.

Given that lump sum transfers are fixed so that net profits are null, government in country i maximizes domestic social welfare given that $\Pi_i = 0$, i.e. maximizes:

$$(1) \qquad \frac{\lambda_i}{2\Lambda^2}(q_1 + q_2)^2 + \left(a - \frac{q_1 + q_2}{\Lambda} - \theta_i\right)q_i.$$

Using these payoff functions, one can derive best response functions and the equilibrium quantities and price of the game are:

$$q_i^s = \lambda_i(a-\theta_i) + \frac{\lambda_j}{2}(\theta_j - \theta_i),$$
$$p = \frac{1}{2}(\theta_1 + \theta_2).$$

The price settles between the two marginal costs and is independent of market sizes. Given our assumption, it is immediate to check that the price under secret regulation is lower than without any regulatory policy. Note also that in this situation the competitive price would be equal to θ_1. Therefore 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 regulated open and protected markets, we find:

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

We thus obtain:

> PROPOSITION 2 : Opening the markets to competition with secret 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 than 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.

3.3. **Public Regulation**

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. It should be noted that, contrary to the case with secret regulation, this game is not equivalent to a game where states would simultaneously choose quantities to be produced by their firms, since in the later situation, quantities would be chosen irrespective of foreign decisions, whereas in the former situation quantities chosen by firms are affected by foreign subsidy rate decisions: the existence of precommitment effects precisely hinges on the possibility for one state to affect the foreign production decision.

The equilibrium is easily characterized. First, for each pair of subsidy rates (s_1, s_2), the Cournot equilibrium can be first computed:

$$q_i(s_i, s_j) = \frac{\Lambda}{3}\{a - 2(\theta_i - s_i) + (\theta_j - s_j)\}, \tag{2}$$

$$p(s_i, s_j) = \frac{1}{3}\{a + (\theta_i - s_i) + (\theta_j - s_j)\}. \tag{3}$$

Then, using the fact that lump sum transfers are again fixed so that net profits are equal to 0, one can look for the equilibrium in subsidy rates where each state follows the objective function described in (1), taking quantities and price as given in (2) and (3). Equilibrium rates are:

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

from which, using (2) and (3) one can deduce equilibrium productions and price:

$$q_i^p = \lambda_i(a-\theta_i) + \frac{\lambda_i + 2\lambda_j}{2}(\theta_j - \theta_i),$$
$$p = \frac{1}{2}(\theta_1 + \theta_2).$$

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: $\frac{\partial W_i}{\partial q_j} = \frac{\lambda_i q_j - \lambda_j q_i}{\Lambda^2}$. 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 [10], 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:

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

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:

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

PROPOSITION 4: With a common market, public regulation Pareto dominates secret regulation.

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10. In particular, the price-elasticities and the number of firms are the same in both countries.

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 [11]. 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.

The previous section has analyzed allocative effects arising from efficiency differences between firms. Such effects would still be present in a model under general private information. In order to isolate the specific effects due to the incompleteness of regulators' information, we consider the case where the cost parameter are equal and therefore perfectly correlated. Note that if costs are identical under perfect information, the welfares under secret and public contracts are equal to the closed economy welfare: there are no strict

11. 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 have to consider $\underline{\theta}$ high enough. In any case, a is assumed to be large compared to costs as previously.

gains to the creation of the common market in this case. Given the symmetry assumption, we omit the country's index whenever it is not necessary.

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]) [12]. 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: $\forall(\theta, \tilde{\theta})$,

$$\Pi(\tilde{\theta}, \theta) = q(\tilde{\theta})(a - \theta - q(\tilde{\theta})) - t(\tilde{\theta}) \leq q(\theta)(a - \theta - q(\theta)) - t(\theta) = \Pi(\theta),$$

and participation constraints: $\Pi(\theta) \geq 0$ for all θ. This is a direct application of BARON and MYERSON [1982], where the revelation constraint is equivalent to its FOC, given by the envelope theorem:

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

and its SOC: $q(.)$ non-increasing. Given that profits must decrease with respect to θ in equilibrium, the participation constraint reduces to:

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

The optimal production and price are obtained by maximizing expected domestic social welfare subject to the FOC of the revelation constraint and the participation constraint, checking afterwards that the resulting quantity is indeed non-increasing in θ. Expected domestic social welfare can be written as:

$$\mathbf{E}\left[\frac{1}{2}(q(\theta))^2 + (a - \theta - q(\theta))q(\theta) - (1 - \alpha)\Pi(\theta)\right],$$

or, using the FOC for the revelation constraint and after an integration by parts of $\mathbf{E}[\Pi(\theta)]$,

$$\mathbf{E}\left[\frac{1}{2}(q(\theta))^2 + (a - \theta - q(\theta) - (1 - \alpha)(\theta - \underline{\theta}))q(\theta)\right].$$

Optimizing pointwise in $q(.)$, one immediately finds:

$$q^A(\theta) = a - \theta - (1 - \alpha)(\theta - \underline{\theta}),$$
$$p^A(\theta) = \theta + (1 - \alpha)(\theta - \underline{\theta}).$$

12. We indeed prove it below.

It is immediate to find that:

$$t^A(\theta) = q^A(\theta)\big(a - \theta - q^A(\theta)\big) - \int_{\theta}^{\underline{\theta}+1} q^A(y)dy.$$

To recover the optimal subsidy rate, note first that for a given announcement $\tilde{\theta}$, a firm facing a subsidy policy $(s(\tilde{\theta}), t(\tilde{\theta}))$ chooses:

$$q(\tilde{\theta}, \theta) = \frac{1}{2}(a - \theta + s(\tilde{\theta})).$$

Therefore, the only possibility for the subsidy rate is:

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

It remains to check that, facing $(s^A(.), t^A(.))$, a firm anticipates that, if it announces $\tilde{\theta}$, it will optimally decide to produce $\left(a - \frac{\theta+\tilde{\theta}}{2} - (1-\alpha)(\tilde{\theta} - \underline{\theta})\right)$ and therefore will earn profits:

$$\left(a - \frac{\theta + \tilde{\theta}}{2} - (1-\alpha)(\tilde{\theta} - \underline{\theta})\right)^2 - t^A(\tilde{\theta}),$$

which are exactly the profits obtained by a firm facing a direct quantity regulation mechanism $(q^A(.), t^A(.))$ and then induce revelation.

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 marginal increase of the social cost of informational rents accrued to firm of types $\theta' \leq \theta$ 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 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 [13].

We are going to study the situation of secret and public regulations with perfect correlation of firms' costs in the context of a common market.

13. 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.

4.2. **Open Market with Secret Regulation**

If contracts are secret, as under perfect information, an equilibrium is 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 1: Under imperfect information and perfectly correlated costs, when regulation contracts are secret, the symmetric linear equilibrium is characterized by the following unitary subsidies, equilibrium productions and price:

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

Proof: See appendix. ☐

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

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

and, since $\frac{dq_j(\theta)}{d\theta} < 0$, 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 [14]. 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 appears in slightly different contexts in CAILLAUD [1990] and BRAINARD and MARTIMORT [1996].

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

14. The rival firm's production is $q_j(\theta) > q_j(\tilde{\theta})$.

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, gross consumers' surplus unambiguously benefits from the opening of a common market. And since moreover agency costs for a given production are reduced, national social welfares are unambiguously improved. Note also that, if productions were the same as under autarchy, rents would be reduced; but the efficiency increase precisely comes from an increase in production which could then offset the reduction of rents through the correlation effect. In fact, one can show that when a is large enough as required by our assumption, it is also true that rents are reduced (a sufficient condition is a such that $q^A(\underline{\theta}+1) > \frac{1-\alpha}{3-\alpha}$). We summarize these results in proposition 5.

PROPOSITION 5: 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.

Proof: See appendix. □

4.3. **Open Market with Public Regulation**

Let us now consider the case of public contracts and see how precommitment effects change the results. States may then 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 $\left(s_i(\widetilde{\theta}_i), t_i(\widetilde{\theta}_i)\right)$ 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 2: Under imperfect information, public regulation contracts and with perfect cost correlation, the symmetric linear equilibrium corresponds to the following unitary subsidies, productions 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 [1996], 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:

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

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

We call this effect 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:

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

If production were the same as under secret regulation, one could immediately conclude that rents are reduced by public disclosure of subsidy policies. We have seen, however, that quantities are increased under public regulation -this is precisely the efficiency effect- so that the overall effect on rents could be ambiguous. In fact, under the same assumption as before guaranteeing that a is large enough (such as $q^A(\underline{\theta}+1)>0$), we can show that the incentive effect of public messages dominates so that 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 contract case. To summarize:

PROPOSITION 6: Under imperfect information and perfect cost correlation, the public disclosure of subsidy policies is welfare improving; compared to the case of secret contract, the price level is reduced, productions are increased and informational rents are reduced.

Proof: See appendix. □

These results are illustrated in figures 1 and 2.

5 Extensions and Discussions

Our results are derived under quite strong assumptions concerning the market structure. Under Cournot competition and perfect information, it is fairly easy to extend the analysis of section 3 to more general cases. We first come back on the assumption of common market. We suppose that, when the two countries decide to open the frontiers, two segmented open markets appear, one in each country: firms bear trade costs on their exports. This induces excessive trade and welfare losses if states cannot discriminate their subsidies between domestic production and exports. Second, we extend our results in the perfectly integrated market model to an arbitrary number of states and of firms and to the existence of exports markets.

5.1. Segmented Markets

This first extension deals with the existence of trade costs: although the integration process allows each firm to produce for both markets, firm i exports a quantity q_{ij} in market j, *with a unitary "transportation cost"* c [15], that is assumed to be small to avoid corner solutions. It also produces a quantity q_{ii} for market i without any supplementary cost. Consumption in state i is:

$$d_i(p)=\lambda_i(a-p_i)=q_{ij}+q_{ji},$$

and the inverse demand function is:

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

15. c may also be seen as capacity cost incurred by one firm when it decides to enter the other country.

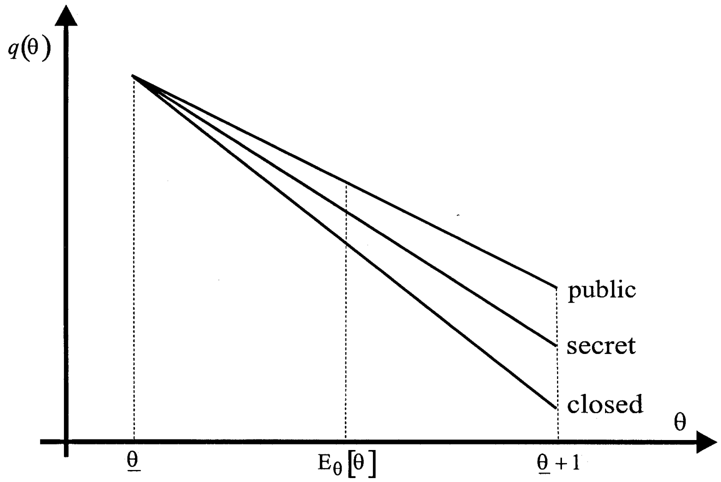

FIGURE 1

Production of firms

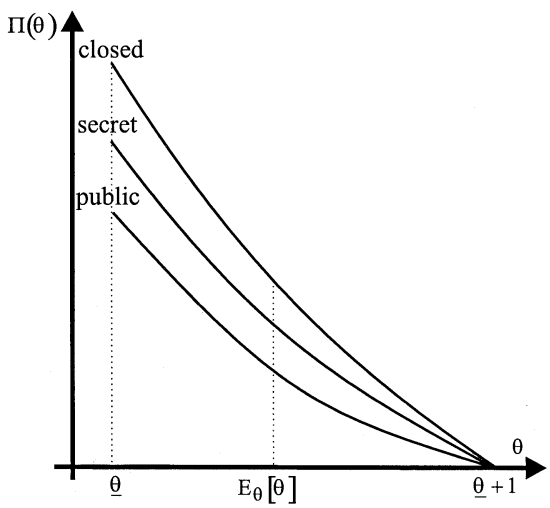

FIGURE 2

Informational rents

Prices can now be different in each market [16].

16. This model is useful to explain intra-industry trade, as in BRANDER [1981]. BEN-ZVI and HELPMAN [1992] present some links between integrated and segmented markets.

5.1.1. **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 prove the equivalence mentioned earlier. In any case (secret or public regulations), firms 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 3: 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:

$$\left(\theta_i + \frac{\lambda_j}{\Lambda}c\right)q_i - \frac{\lambda_1\lambda_2}{\Lambda}c^2.$$

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 $\theta_i + \frac{\lambda_j}{\Lambda}c$ and fixed profit $\frac{\lambda_1\lambda_2}{\Lambda}c^2$. The results of section 2 still apply. In particular, the equilibrium price and quantities are:

$$p_i = \frac{1}{2}(c + \theta_1 + \theta_2),$$

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

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

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:

$$q_{ij}^s - q_{ji}^s = \frac{\Lambda}{2}\left(\theta_j + \frac{\lambda_i}{\Lambda}c - \theta_i - \frac{\lambda_j}{\Lambda}c\right).$$

One obtains proposition 7:

PROPOSITION 7: 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 therefore tends 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 [17].

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17. 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]).

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:

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

We thus obtain:

PROPOSITION 8: 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.

5.1.2. **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 4: 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 $p_i = \frac{1}{2}(\theta_1 + \theta_2 + c)$ 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 9: With segmented markets, if one state regulates its domestic firm, it is optimal to allow export subsidies in the other state.

5.2. **Arbitrary Number of States and Firms, Export Markets**

We now propose an extended model allowing for an arbitrary number of states and firms and for export markets. Markets are assumed perfectly integrated. Without surprise, national states prefer the open economy (with secret or public regulatory contracts) to autarchy. The section thus focuses mainly on the differences in the price level and in national welfare with public and secret contracts.

5.2.1. **The Model**

We assume now that the integration process concerns k markets, each with a linear demand equal to: $a - p$. Among these, n markets belong to states that regulate their firms. There are n_i regulated firms per state, with constant marginal cost θ_i. There are also m active firms that are not subsidized and produce with a marginal cost θ_f. This cost is assumed small enough so that they effectively produce. These firms can be considered either as local private firms or as foreign importing firms. We let $N = \sum_{i=1}^{n} n_i$ denote the total number of subsidized firms and $M = m + N$ the total number of firms. $k - n$ is the number of export markets. Q_i is state i national production and X the production of the non-regulated firms. The total production is $Q = \sum_{i=1}^{n} Q_i + X$.

The game is the same as previously. In the first stage, the n states choose non-cooperatively their transfers, unitary subsidy and lump-sum, (s_i, t_i). In the second stage, the M firms compete in the common market where the inverse demand function is:

$$p = a - \frac{Q}{k}.$$

Clearly, as in section 3 and because information is perfect, the lump-sum transfers are chosen so as to set the net profit of regulated firms to zero. The subsidy rate is then fixed in each state so as to maximize the national welfare given by:

$$\begin{aligned} W_i &= \frac{(a-p)^2}{2} + (p - \theta_i)Q_i \\ &= \frac{Q^2}{2k^2} + \left(a - \frac{Q}{k} - \theta_i\right)Q_i. \end{aligned}$$

Allowing an arbitrary number of states and firms induces differences in the effects of the marginal subsidies on the national and total productions. We define:

$$T_i = \frac{\frac{\partial Q_i}{\partial s_i}}{\frac{\partial Q}{\partial s_i}} \geq 1,$$

where the quantities are the equilibrium quantities in the firms' game, for fixed level of subsidies.

If $T_i = 1$, the other states' production is not responsive to s_i. This is the case under secret contracts. If $T_i = +\infty$, the reaction of the other states completely offsets the impact of s_i on Q_i, so that the total quantity is unchanged (an example is perfect competition in the other state with a cost below $\theta_i - s_i$). Under public contracts, we have: $T_i = 1 + M - n_i$. Now, the conditions for the equilibrium are, from the first-order conditions of the first stage of the game in subsidies:

$$Q_i = \frac{Q}{k} + kT_i(p - \theta_i),$$

and, from the market equilibrium:

$$X = mk(p - \theta_f).$$

These two conditions summarize the necessary information to compute the equilibrium. We obtain:

$$Q = \frac{k}{\sum_{i=1}^n T_i + \frac{k-n}{k} + m}\left(a\left(\sum_{i=1}^n T_i + m\right) - \sum_{i=1}^n T_i\theta_i - m\theta_f\right),$$

$$p = \frac{1}{\sum_{i=1}^n T_i + \frac{k-n}{k} + m}\left(a\left(\frac{k-n}{k}\right) + \sum_{i=1}^n T_i\theta_i + m\theta_f\right).$$

We have to be careful to interiority conditions of X and Q_i given by:

$$p > \theta_f \quad \text{if} \quad m > 0,$$

$$kT_i(\theta_i - p) > \frac{Q}{k} \quad \text{if} \quad \theta_i > p.$$

There is no problem of interiority if a is sufficiently large compared to the number of states and firms.

It is easy to compute the welfare variation, denoted V_i, between the closed economy and the common market:

$$V_i = W_i - \frac{(a - \theta_i)^2}{2} = \left(kT_i - \frac{1}{2}\right)(p - \theta_i)^2 > 0.$$

We define:

$$\widehat{\theta} = \frac{\sum_{i=1}^n \theta_i}{n},\ \gamma = \frac{\sum_{i=1}^n n_i\theta_i}{N},\ \alpha = \frac{k-n}{k} + m,\ \delta = \frac{\frac{k-n}{k}a + m\theta_f}{\frac{k-n}{k} + m}.$$

Under secret contracts, the price and welfare gain in equilibrium are then given by:

$$p^s = \widehat{\theta} + \frac{\alpha}{n + \alpha}(\delta - \widehat{\theta}),$$

$$V_i^s = \left(k - \frac{1}{2}\right)(p^s - \theta_i)^2.$$

Under public contracts, we have:

$$p^p = \widehat{\theta} + \frac{N(\widehat{\theta}-\gamma)+\alpha(\delta-\widehat{\theta})}{n(M+1)-N+\alpha},$$
$$V_i^p = \left(kT_i - \frac{1}{2}\right)(p^p-\theta_i)^2.$$

Proposition 10 is obtained:

PROPOSITION 10: Creating a common market with secret or public contracts increases social welfare, whatever the number of states, firms and markets.

The price variation between public and secret contracts is:

$$p^p - p^s = \frac{nN(\widehat{\theta}-\gamma)+nM\alpha(\widehat{\theta}-\delta)+\alpha N(\delta-\gamma)}{(n(M+1)-N+\alpha)(n+\alpha)},$$

whereas welfare in state i is higher under public contracts if:

$$\left(\frac{p^p-\theta_i}{p^s-\theta_i}\right)^2 > \frac{1}{1+\frac{2k}{2k-1}(M-n_i)}.$$

We now study these differences in various situations.

5.2.2. **Arbitrary Number of States and Firms Without Export Markets and Without Private Firms**

We assume here that there are no export markets and no non-regulated firms, either private or foreign. We then have: $k = n, \alpha = 0, M = N$. The equilibrium prices are given by:

$$p^s = \widehat{\theta},$$

$$p^p = \widehat{\theta} + \frac{N(\widehat{\theta}-\gamma)}{n(N+1)-N} = p^s + \frac{N(\widehat{\theta}-\gamma)}{n(N+1)-N}.$$

The price tends towards the cost of the state with the smallest number of firms. Note that the welfare gain from the creation of the common market increases with the number of states.

If there is only one regulated firm by state, the price is equal under secret and public contracts to the average of the marginal costs of firms. The welfare gain is higher under public contracts, the higher the number of states:

$$V_i^p = \frac{\left(N^2-\frac{1}{2}\right)}{\left(N-\frac{1}{2}\right)}V_i^s.$$

Precommitment effects due to an asymmetry in the number of regulated firms are easy to understand in the two-country case. We assume $n = 2$ and $n_2 = 1$, and increase n_1. Then p^p tends to θ_2, while $p^s = \widehat{\theta}$ stays fixed:

$$p^p - \theta_2 = \frac{2(\theta_1 - \theta_2)}{N+2}.$$

As $N = n_1 + 1$ gets large, state 2 starts losing from precommitment effects. The reason is that state 2 cannot affect the price which tends to be equal to the perceived cost in state 1, $\theta_1 - s_1$. State 1 then controls the price and gets all the benefits due to precommitment effects. The study of the welfare gains leads to proposition 11:

PROPOSITION 11: Public contracts Pareto dominate secret contracts whatever the number of states and regulated firms provided that this number does not differ too much across states.

The cooperative nature of the game with public policies is then robust to the number of states and to varying the number of firms within each state, provided that there is not too much difference between the degrees of concentration. This corresponds to the situation of interest for us since we focus on the impact of trade on historically protected regulated industries. In this case, strategic effects push the price towards the cost of the state with the least number of firms. When the asymmetry is large, and in particular if one state is close to a competitive structure, the other state may be hurt by strategic effects, the reason being that the ability to exploit strategic commitment effects is increasing with the competitiveness of the national industry [18].

5.2.3. **Export Foreign Markets**

Suppose now that firms also export on foreign markets integrated with national markets, and that national regulators subsidize total national production. Our parameters are given by:

$$k > n, \alpha = \frac{k-n}{k} > 0, \delta = a > \widehat{\theta}, M = N = n, m = 0, \gamma = \widehat{\theta}, n_i = 1.$$

This leads to the following prices under public and secret contracts:

$$\widehat{\theta} < p^p = \widehat{\theta} + \frac{\alpha(a - \widehat{\theta})}{n^2 + \alpha} < p^s = \widehat{\theta} + \frac{\alpha}{n+\alpha}(a - \widehat{\theta}).$$

Welfare is higher under public contracts if:

$$\left(\frac{p^p - \theta_i}{p^s - \theta_i}\right)^2 > \frac{1}{1 + \frac{2n}{2n+\alpha-1}(n-1)},$$

18. Indeed, if the industry is fully competitive in state 1 and oligopolistic in state 2, state 1 can control the final price which is $\theta_1 - s_1$.

which is the case if the number of states that regulate their firms is large.

For example, if $n = 2$, we have:

$$\widehat{\theta} < p^p = \frac{4\widehat{\theta} + \alpha a}{4 + \alpha} < p^s = \frac{2\widehat{\theta} + \alpha a}{2 + \alpha},$$

and welfare increases if:

$$\left(1 + \frac{\theta_j - \theta_i}{\theta_j - \theta_i + \alpha(a - \theta_i)}\right)^2 > \frac{3 + \alpha}{7 + \alpha}\left(\frac{4 + \alpha}{2 + \alpha}\right)^2.$$

This is true if α is small, but false if α is close to 1. Moreover, the ratio $\frac{V^p}{V^s}$ is larger for the low cost state. Our results are summarized in proposition 12:

PROPOSITION 12: The price is lower under public contracts than under secret contracts. The welfare gain is higher under public contracts for a small foreign market, lower for a large foreign market. For a medium size foreign market, it is higher under public contracts in the low cost states and lower in the high cost states.

The presence of foreign markets shifts the states' behavior towards profit maximization. The model is thus in between our model and the BRANDER and SPENCER [1985] model of international market share rivalry. The price level is thus higher than without export markets. Commitment effects reduce the price level as in Brander and Spencer. The impact on welfare is ambiguous because these precommitment effects are opposite to the ones described in the previous sections that reinforce the reallocation of the production and coordinate the strategic trade policies.

5.2.4. **Imports**

Suppose now that the market is served by national producers, but also by foreign producers [19]. These producers are not subject to trade barriers. The model only makes sense if these foreign producers have a marginal cost lower than the average national marginal cost, which we assume (otherwise the price settles as in section 3, and there is no import). We also assume for the sake for simplicity that there are no export markets and that only one firm per state is regulated. Our parameters are:

$$k = n, \alpha = m, \delta = \theta_f < \widehat{\theta}, M = N + m > N = n, m > 0, \gamma = \widehat{\theta}, n_i = 1.$$

Prices are given by:

$$p^s = \widehat{\theta} - \frac{m}{n + m}(\widehat{\theta} - \theta_f) < p^p = \widehat{\theta} - \frac{m}{n^2 + nm + m}(\widehat{\theta} - \theta_f).$$

19. These firms can also be private, non-regulated firms.

We have to be careful about interiority if m is large, because T_i goes to infinity.

Welfare increases when contracts are public, compared to secret contracts, if:

$$\left(\frac{p^p-\theta_i}{p^s-\theta_i}\right)^2 > \frac{1}{1+\frac{2n}{2n-1}(n+m-1)}.$$

This is true if n is large compared to m.

More particularly, in the two-country case ($n=2$), welfare increases if:

$$\left(1+(1+m)\frac{\theta_j-\theta_i}{\theta_j-\theta_i+m(\theta_f-\theta_i)}\right)^2 > \frac{3}{7+4m}\left(\frac{4+3m}{2+m}\right)^2.$$

If $\theta_2 = \theta_1$, welfare decreases.

If $\theta_f = \theta_1$, we obtain for state 1:

$$(2+m)^2 > \frac{3}{7+4m}\left(\frac{4+3m}{2+m}\right)^2,$$

which is true for m small.

For state 2, it comes:

$$4 > \frac{3}{7+4m}\left(\frac{4+3m}{2+m}\right)^2,$$

which again is true for m small. This leads to proposition 13:

PROPOSITION 13: When foreign firms import to the common market, welfare gains are higher for the high cost country. Secret contracts may be preferred, if the importing firms' cost is very low.

The presence of low cost importers reduces the level of the price below national cost, in an attempt from states to capture part of the importers' rents. Two situations may arise. In the first situation, the price settles between the national marginal costs and the analysis is along the lines of section 3, with higher welfare under public contracts. Moreover, commitment effects increase the price level. In the second situation, national marginal costs are above importers' costs. In this case, the price is below all national costs. Regulation is then costly since states produce below marginal costs. States then face a free rider problem in marked contrast with the situation that characterizes export markets: each states would like the other state to subsidize more and to pay the cost to reduce the price below $\widehat{\theta}$. Subsidies are now strategic substitutes, whereas they were complement in our previous game. As a result, marginal subsidies decrease, the price increases and national welfare decreases when contracts are assumed to be public.

6 Conclusion

This work analyzes 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 show 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 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.

In our analysis of informational rents, we have focused on the case of perfect correlation between the marginal costs of firms. In a companion paper (Caillaud *et al.* [1997]), we show that new signalling effects arise when costs are not perfectly correlated. The public disclosure of a contract may then serve as a signalling device not only on the subsidy rate the firm is facing but also on the true cost parameter of the firm. This last signalling component is reminiscent to Caillaud and Hermalin [1993].

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 [1996], 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 *et 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.

A Proof of Lemma 1

We first concentrate on the game with quantities directly and simultaneously chosen by states in revelation contracts such as $(t_i(.), q_i(.))$. 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:

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

The revelation constraints for $(t_i(.), q_i(.))$ are then equivalent to the following conditions:

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

Government i's welfare is given by:

$$\mathbf{E}_\theta\left[\frac{1}{2}\left(\frac{q_i(\theta) + q_j(\theta)}{2}\right)^2 + \left(a - \frac{q_i(\theta) + q_j(\theta)}{2} - \theta\right)q_i(\theta) - (1-\alpha)\Pi_i(\theta)\right].$$

Using the FOC for the revelation constraint and integrating $\mathbf{E}_\theta[\Pi_i(\theta)]$ by parts, government i's welfare can be transformed into:

$$\mathbf{E}_\theta\left[\frac{1}{2}\left(\frac{q_i(\theta) + q_j(\theta)}{2}\right)^2 + \left(a - \frac{q_i(\theta) + q_j(\theta)}{2} - \theta - (1-\alpha)\left(1 + \frac{\dot{q}_j(\theta)}{2}\right)(\theta - \underline{\theta})\right)q_i(\theta)\right].$$

Given that, one immediately gets that the informational rent for the worse type of firm must be equal to 0: $\Pi_i(\underline{\theta} + 1) = 0$.

Optimizing pointwise these social objectives where the FOC incentive constraint has been plugged in determines the profile $q_i(.)$ as a candidate best response to the competitor's production profile $q_j(.)$:

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

and given the concavity of the program, this equation is necessary and sufficient for optimality.

Looking for a symmetric equilibrium, the above equation determines a differential equation for the symmetric equilibrium productions:

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

with linear solution given by:

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

It remains to check that the second order revelation constraint is indeed satisfied for this production profile. Hence the equilibrium quantities and price given in the Lemma.

One can finally recover the linear subsidy term by noticing that the optimal choice of production by a firm facing a linear subsidy policy $(t_i(\tilde{\theta}), s_i(\tilde{\theta}))$, when it expects its rival to produce according to $q_j(.)$, is given by the following program:

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

The optimal subsidy rate must then necessarily be chosen so that the above solution coincides with $q^{SP}(\theta)$, when $\tilde{\theta} = \theta$ and $q_j(.) = q^{SP}(.)$. Thus,

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

Finally, one can easily check that the incentive problem of a firm facing this linear subsidy policy is identical to the revelation problem it faces in the quantity contract. □

B Proof of Proposition 5

Note first that since for (almost) all θ, $p^{SP}(\theta) < p^A(\theta)$, the expected objective of a state in terms of pure efficiency, i.e. the expected value of the consumers' surplus plus the firm's gross profit $(S_i + \pi_i)$, increases under a common market with secret regulation compared to the case of autarchy.

Total expected welfare also includes informational rent. $\Pi^{SP}(\theta)$ and $\Pi^A(\theta)$ turn out to be a decreasing convex functions of θ, both equal to 0 at $\underline{\theta}+1$. Comparing their slopes, one can compute the difference $\frac{d\Pi^{SP}}{d\theta} - \frac{d\Pi^A}{d\theta}$; it is equal to:

$$\left(1 - \frac{1}{3-\alpha}\right)\left[a - \theta - (1-\alpha)(\theta - \underline{\theta})\left(1 + \frac{1}{3-\alpha}\right)\right].$$

Note that the first term of the product is positive. The difference in slopes is always positive under our assumption that a is large enough, but it is indeed sufficient, given the monotonicity in θ, that $q^A(\underline{\theta}+1) > \frac{1-\alpha}{3-\alpha}$. If this is the case, then informational rents are also reduced under the common market and welfare comparisons follow. $\square$

C Proof of Lemma 2

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

$$q_i(\theta, s_i, s_j), = \frac{2}{3}(a - \theta + 2s_i - s_j),$$
$$p(\theta, s_1, s_2) = \frac{1}{3}(a + 2\theta - s_1 - s_2).$$

From these, one can deduce the utility of firm i, facing the subsidy policy $(t_i(.), s_i(.))$, when it decides to misrepresent its cost parameter by announcing $\tilde{\theta}$, and when its opponent truthfully announces θ:

$$\Pi_i(\tilde{\theta}, \theta) = \frac{1}{2}q_i(\theta, s_i(\tilde{\theta}), s_j(\theta))^2 - t_i(\tilde{\theta}).$$

The FOC for the revelation constraint of firm i, assuming that the other firm announces the truth, reduces to:

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

The following second order condition has also to be satisfied:

$$\frac{ds_i(\theta)}{d\theta}\left(1 + \frac{ds_j(\theta)}{d\theta}\right) \leq 0,$$

and these conditions are sufficient to ensure truthful revelation of firm i.

If the slope of the subsidy is between -1 and 0, the rent is positive for all types when $\Pi_i(\underline{\theta}+1) \geq 0$. We focus on the unique symmetric equilibrium [20]. For this equilibrium, we can ignore the second order incentive constraint and set $\Pi_i(\underline{\theta}+1) = 0$. One can then verify ex-post that all the constraints are verified.

After integrating by parts $\mathbf{E}_\theta[\Pi_i(\theta)]$ and using the FOC for the revelation constraint, the government's welfare can then be written as:

$$\mathbf{E}_\theta\left[\frac{1}{2}(a - p(\theta, s_i(\theta), s_j(\theta)))^2 + (p(\theta, s_i(\theta), s_j(\theta)) - \theta)q_i(\theta, s_i(\theta), s_j(\theta)) - (1-\alpha)\frac{2}{3}q_i(\theta, s_i(\theta), s_j(\theta))(1 + \dot{s}_j(\theta))(\theta - \underline{\theta})\right].$$

20. Whether there also exist asymmetric equilibria eventually involving some bunching is an opened question.

Pointwise optimization of these objectives yields a FOC that characterizes $s_i(.)$ as a best response to $s_j(.)$:

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

and this first order maximization condition is sufficient given that the objective function is quadratic concave in $s_i(.)$.

The symmetric equilibrium, corresponding to a linear solution of the above equation where $s_j(.) = s_i(.)$, is given by:

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

It is now possible to check that this subsidy rate satisfies the second order revelation constraint and is indeed a solution to our initial problem. Finally, it is immediate to find the quantity and price mentioned in the Lemma, using the expression of the Cournot continuation equilibrium given at the start of the proof. □

D Proof of Proposition 6

Note first that since for (almost) all θ, $p^{PP}(\theta) < p^{SP}(\theta)$, the expected objectives of a state in terms of pure efficiency, i.e. the expected value of the consumers' surplus plus the firm's gross profit ($S_i + \pi_i$), increase under a common market with public regulation compared to the case of secret regulation, and a fortiori compared to the case of autarchy.

Total expected welfare also includes informational rent. $\Pi^{PP}(\theta)$ and $\Pi^{SP}(\theta)$ turn out to be a decreasing convex functions of θ, both equal to 0 at $\underline{\theta}+1$. Comparing their slopes, one can compute the difference $\frac{d\Pi^{PP}}{d\theta} - \frac{d\Pi^{SP}}{d\theta}$; it is equal to:

$$\left(\frac{1}{3-\alpha} - \frac{1}{3(2-\alpha)}\right)\left[a - \theta - (1-\alpha)(\theta - \underline{\theta})\left(\frac{1}{3-\alpha} + \frac{1}{3(2-\alpha)}\right)\right].$$

Note that the first term of the product is positive. The difference in slopes is always positive under our assumption that a is large enough, but it is indeed sufficient, given the monotonicity in θ, that $q^A(\underline{\theta}+1) > 0$, since:

$$\frac{1}{3-\alpha} + \frac{1}{3(2-\alpha)} < 1.$$

Since this must be the case for our previous analysis, informational rents are also reduced under the common market with public regulation and welfare comparisons follow. □

E Proof of Lemma 3

Suppose that there are no taxes and that firm i anticipates productions q_{jj} and q_{ji}. For a fixed production q_i, it will allocate the production across market so as to solve:

$$\max_{q_{ii},q_{ij}} (p_i - \theta_i)q_{ii} + (p_j - \theta_i - c)q_{i,j}$$
$$\text{subject to } q_i = q_{ii} + q_{ij},$$

and with inverse demand functions given by:

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

This leads immediately to:

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

With taxes based on total production, the cost is now $\theta_i - s_i$, and the result still applies. The lemma then follows directly. □

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