Regulatory Competition and Exclusion in an International Context*

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Abstract

Regulatory competition is a hot topic. We show that when regulators contract simultaneously with a multinational rm then there exists a risk of exclusion of one regulator. We study this phenomenon in a setting where a multinational rm allocates common costs between its two subsidiary and has different ownership shares in the two subsidiary rms. The paper also provides the rst characterization of an PBE in a multiprincipal (or common agency) game with asymmetrically uniformed Principals. We then study asymmetric equilibria in which one of the regulators (the Principals).

Keywords: Multinational Enterprises, Regulation, Asymmetric Information, Multiprincipal, Common Agency.

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1 Introduction

Multinational enterprises (hereafter Mne) are now populating traditionally regulated sectors such as railway, electricity, telecommunication, banking and insurance. Multiproduct rms and conglomerates considerably increase the difficulty of regulators tasks given the numerous links between rm s activities. On top of that, MNEs, which are by de nition multiproduct rms, represent speci c and relatively new concerns for regulators for at least two reasons. First, the rules imposed by a regulator in country A may well affect the behavior of the multinational in country B. Thus, each regulator has to recognize that the optimal policy affects and depends on the policy in place in the other countries. In other words, regulators face a problem of common agency. Second, MNEs may have the possibility to ... *escape the regulatory reach of any national government* (Caves (1996) page 257). These rms are in a position to play national regulations each against the others and take advantage of the difference in national regulating schemes and this ability is indeed an additional constraint in regulators task. There exists in fact the possibility that one country which sets a tough regulation, may induce the rm to y abroad and serve only foreign markets. In this paper we analyze these two main concerns showing how regulations interfere and how regulators may nd themselves excluded from the MNE s services.

An important link between multinational activities arises from the production process. The cost of producing intermediate or nal goods may be non separable (this is the case of R&D expenses and general and administrative costs such as accounting) and allocation rules must be employed to determine pro ts earned by the MNEs in the several countries in which it is active. We will show that allocation rules themselves link output productions and national regulations.[1]

The issues encountered by national regulators in facing MNEs are complicated by the fact that MNEs have multiple reasons to differently evaluate pro ts earned in different countries. For example, corporate tax rates may differ among countries or the Mne may only partially own certain subsidiaries. Limited pro t repatriation rules may also play a major role as pro t locked

[1] Similarly, a MNE may produce an intermediate good in Asia, and sends it to other subsidiaries rms located in Europe and/or in the US. In this case too there is the issue of properly allocating the input production costs among the MNE s subsidiaries (multinational transfer pricing) and this process may again give rise to connection between output productions and regulations.

in one country may well be less valuable than the ones free to be reinvested abroad. Finally, interest rate differential, exchange rate risk and political instability are other well documented facts inducing MNEs to attach different weights to pro ts earned in different countries. It is then clear that the MNE s preferences over pro ts earned in international markets may well rise the tensions in the regulation process among national authorities. With this respect it is interesting to study the underlying parameters which render the competing national regulations compatible or not. Markets characteristics and MNE s preferences over subsidiaries pro ts seem to be the main drivers of the players incentives. Moreover, externalities among regulatory contracts and competition to obtain the rm s services are worthily investigated.

As it is well known, an important aspect in the issue of regulation is the asymmetry of information between the regulating authority and the regulated rm. Hence, in this paper we will model regulation along the lines of the asymmetric information literature. The rm is privately informed on production-relevant parameters, more speci cally, production in each country is characterized by a country speci c parameter. Each regulator share with the rm the exact knowledge of local production but is uninformed on the foreign production parameters. This realistic setting represents the fact that local regulators generally have better knowledge on local markets and technologies than foreign regulators (due, for example, to previous interactions with the local subsidiary). The existing literature on regulation in an international setting (see, for example, Bond and Gresik 1996 and Calzolari 1999) deals with symmetrically uninformed regulators, the main reason being the lack of a theoretical model with asymmetrically uninformed regulator. Our paper, then, provides not only an economic analysis of the highlighted regulation issues, but also the rst theoretical tool to solve multi-principal Agent relationship with asymmetrically uniformed principals.[2]

We will show that the presence of asymmetric information among national regulators will exacerbate the con ict among regulators themselves. Asymmetric equilibria in which the rm produces for one country only (regulator exclusion) will prevail more often than in the case in which regulators are symmetrically uninformed. Moreover, the same Mne may end up worse off with respect to a situation in which faces symmetrically (un)informed

[2] Indeed the, by now, vast literature on multiprincipal and common agency very often deals with economic examples which t much better in the case of asymmetrically uninformed Principals.

regulators. Surprisingly we will also show that with asymmetrically uninformed regulators, regulator exclusion will be softened with respect to the full information case.

The existing literature on common agency has always dealt with equilibria in which the agent prefers to participate with both the Principals. Same papers exclude exogenously the possibility to have equilibria with the Agent participating with only one Principal (the intrinsic common agency approach), some others, even if allowing for Principals exclusion, they however focus on equilibria with no exclusion. We think that in some contexts it may be much more realistic to consider explicitly the competition effects which arises in common settings. The international arena with competing national regulation, for example, clearly asks for a deep investigation of the phenomenon of rms attraction by countries. In this paper we will show that national regulators may indeed build so a erce competition that they are unable to have the rm producing for all of them. Moreover, competition arises as a result of the tensions within the Mne incentives (eventually leading to implicit exclusion), but can also be due to an explicit strategy of national regulators (eventually leading to voluntary exclusion).

In section 2 we present the model. In section 3 we study international regulation with full information with and without exclusion. Section 4 deals with regulation by un-informed regulators and study the case in which both regulators are able to have the rm serving the local market. In section 5 we study exclusion and in section 6 the extensions. Section 7 concludes the paper. All the proofs are in the appendix.

2 The model

The rm A regulated multinational serves two countries: country d (for the sake of concreteness d stands for domestic country) and country f (the foreign country) and is regulated by the national authorities. The rm produces an amount $Q = q_d + q_f$ of an intermediate good at cost $C(Q) = \frac{1}{2}Q^2$. Inputs q_d and q_f are then transferred to subsidiary divisions located in the two countries. Final stage divisions transform the intermediate inputs to obtain nal outputs and sell them in local markets. The transformation takes place at marginal costs θ_d and θ_f respectively for subsidiary d and f. The total production cost to obtain quantities q_d and q_f of nal outputs, $\theta_d q_d + \theta_f q_f + Q^2$, is then composed by separable (the rst two terms) and non-separable or common costs (the third term). The MNE is allowed to allocate all the separable costs ($\theta_i q_i$) against local income (earned in country i). The common costs are allocated between the domestic and foreign sources according to sales. Thus subsidiary i is charged q_i/Q of total common costs. Such an apportionment rule for common costs of MNEs, called volume-based allocation, is diffusely employed by many countries tax authorities for research, development and experimentation expenses and for general expenses such as interest rates and administrative overhead (see Hines (1993) for a comprehensive description on R&D). The rational for this kind of apportionment rule is that facing non-separable costs authorities try to allocate them according to cost drivers (i.e. nal outputs).[3] Finally, let $p_i(q_i) = a_i - b_i q_i$ denote the inverse demand function of country i. The pro t of the divisions can be expressed as

$$\begin{aligned} \pi_d &= [p_d(q_d) - \theta_d]q_d - q_d(q_d + q_f) - T_d(q_d) \\ \pi_f &= [p_f(q_f) - \theta_f]q_f - q_f(q_d + q_f) - T_f(q_f) \end{aligned}$$

where $T_i(q_i)$ is the instrument used by country i to regulate local production (see later on this).[4] The total pro t of the MNE is given by:

$$\pi = \pi_d + \delta \pi_f. \tag{1}$$

It is a well established fact that the MNEs evaluate differently domestic and foreign pro ts for multiple reasons. First, corporate tax rates differ between countries. Second, there exists a large empirical evidence showing

[3] The same logic is at the basis of the ABC cost allocation rule employed by rms for internal incentives.

[4] In a previous version of the model we study the case of transfer pricing instead of common cost allocation. Employing the standard arm s length transfer pricing rule we show that the model is observationally equivalent to the one we present here and the most important result of the paper holds. As a matter of fact, transfer price regulations are just rules to allocate costs between different subsidiaries.

[4] Even if the increased international tax competition tends to level out these differences, there exists a large empirical evidence showing substantial corporate tax differentials. See Giovannini et al. (1993). Moreover, note that corporate taxes are generally set by governments to achieve objective which are independent to regulation issues and can then be considered as exogenous to our model. There exists vast empirical and theoretical literature dealing with international tax differentials, MNEs cost allocation and transfer pricing regulation. For empirical works, see among the others, Jacob (1996), Rousslang (1997). For theoretical works see Prusa (1990), Gresik and Nelson (1994), Elitzur and Mintz (1996), Schjelderup and Weichenrieder (1996), Gresik (1997a).

that rms tend to be linked in a complex network of cross- rms and cross-countries ownership shares. Shareholders dispersion is such that rm A may have the power to take all the relevant economic decisions of rm B owning only a relatively small share of B (see UNCTD (1996)). Third, limited pro t repatriation is often used as a regulation device with MNEs. Empirical evidence shows that this obligation makes MNEs weighting foreign pro ts less than domestic ones. Finally, interest rate differential, exchange rate risk and political instability are other well documented facts inducing MNEs to attach different weights to pro ts earned in different countries.

Deriving the pro t function (1) with respect to the two outputs

$$\frac{\partial^2 \pi}{\partial q_d \partial q_f} = -(1+\delta).$$

We see that for any value of δ outputs are substitutes and the larger is δ the more substitutes they are.

[4]Let t_d and t_f respectively be the domestic and foreign corporate tax rates such that the post-tax pro t earned by the MNE in country i is $(1-t_i)\pi_i$. Let α denote the MNE s owner share in the foreign located subsidiary and $1-\alpha$ the share owned by other rms. Then, $\alpha\pi_f$ is the MNE s evaluation of foreign before-tax pro ts. In the case of limited pro t repatriation, for any unit of operating pro t the foreign subsidiary can immediately remit only a fraction β of the earned pro t to the parent rm. The remaining $1-\beta$ has to be reinvested in the foreign economy at least for a certain length of time. Letting i be an overall measure of the interest rate differential between countries driven, then home and foreign post-tax pro ts turn out to be weighted respectively by $(1+i)$ and 1. Putting together all the previous consideration one can write the total pro t which the MNE seeks to maximize, as

$$\pi = (1+i)\left[(1-t_d)\pi_d + \beta\alpha\,(1-t_f)\pi_f\right] + (1-\beta)\alpha\,(1-t_f)\pi_f.$$

The previous formula leads to an equivalent reduced form for the MNE s pro t in which the domestic s and foreign pro ts are respectively evaluated with weights 1 and $\delta \in \Re_+$. Whenever $\delta < 1$ (for one, some or all the alleged reasons), the MNE evaluates foreign pro ts less than domestic ones and the countrary is true for $\delta > 1$. For example, Prusa (1990), Gresik and Nelson (1994) employ a setting in which a MNE is subject to limited pro t repartiation. Elitzur and Mintz (1996) study a model in which a MNE evaluates foreign pro t according to its ownerhip share. See, also, Prusa (1990), Gresik and Nelson (1994) and Gresik (1997b).

[4]It is interesting to note that the link between the two outputs would be still effective also in the case in which the common cost to split were a constant F. In fact, consider a rm producing with xed size common facility at cost F with no other production costs. The cost allocated to subsidiary i is $F\,q_i/(q_d+q_f)$ and then$\partial^2\pi/\partial q_d \partial q_f = -F\delta(q_d-q_f)/Q^3 \neq 0$

Informational structure and the regulatory game Outputs are regulated in both countries. The rm is perfectly informed about the cost parameters (θ_d, θ_f) of both divisions but the national regulators are not. Instead, each regulator is perfectly informed about the parameter of the local branch of the MNE but not about the one abroad.[5] In other words, regulator i knows perfectly θ_i but only knows (and this is common knowledge) that the marginal cost θ_j distributes according to a density $f_j(\theta_j)$ on the support $[\underline{\theta}_j, \overline{\theta}_j]$. To simplify the analysis marginal costs are assumed to be un-correlated, however our analysis would carry over for any degree of correlation (also perfect). We assume that production costs are not observable by regulators which only observe the quantity sold in their own market and not in the other market.[6] Regulators therefore offer indirect contracts (here non linear tariff) $T_i(q_i)$ based on local sales. Regulators compete in contracts and play simultaneously. Contracts are secret, meaning that a regulator cannot condition its contract on the other regulator s one. The regulator i s objective is to maximize the (expected) net consumers surplus $\int_0^{q_i} p_i(x)dx - p_i(q_i)q_i$ plus the tariff he gets from the rm,[7]

$$SW_i = \int_{\underline{\theta}_j}^{\overline{\theta}_j} \left\{ \int_0^{q_i} p_i(x)dx - p_i(q_i)q_i + T_i(q_i) \right\} f_j(\theta_j)d\theta_j \quad i, j = d, f \qquad (2)$$

where $q_i = q_i(\theta_d, \theta_f)$. Note that as regulator i knows the true value of local marginal cost θ_i, she takes expectation w.r.t. θ_j only.

In economically integrated areas, such as EU, equity arguments prevent national authorities to discriminate among rms on the basis of their localizations. We thus assume that regulators can not offer a menu of contracts

as long as $q_d \neq q_f$. Interestingly outputs may become endogenously complements or substitutes (respectively when $q_d < (>) q_f$. This example is presented in Calzolari (1999). Thus the analysis of our paper qualitatively extends also to the case of common xed costs.

[5] Differently from our setting, the asymmetry of information could be on intermediate inputs production. See Bond and Gresik (1996) and Calzolari (1998).

[6] Alternatively, foreign output could be observable but national regulators are not allowed to regulate foreign outputs and condition their instruments on these variables. After all jurisdictional power of regulating authorities is limited to national boundaries and regulators are thus allowed to regulate only domestic production.

[7] Our results would qualitatively hold also if the regulators evaluated also MNE s pro ts according to country speci c weights. For this kind of analysis see Calzolari (1999).

which are in force when the rm produces locally or when it chooses to be a MNE (thus serving both markets), but can only offer a unique regulation.

We model the international competition between regulatory authorities letting the MNE to serve (or be active in) both, one or none of the countries. Thus, each regulator has to take into account that if she sets too a tough regulation she may induce the rm to y abroad and serve only the other market.[8] This possibility will be explicitly studied in the following analysis which then proves to be somehow innovative with respect to the common agency literature.

3 Non cooperative regulations and complete information

In this section only, we assume that both regulators as well as the Mne perfectly know both marginal costs θ_d and θ_f. The programs of the regulators under complete information can be stated as follow:

$$\{ \ q_i, T_i \max \int_0^{q_i} p_i(x)dx - p_i(q_i)q_i + T_i(q_i) \text{subject to } \pi_{df} \geq 0$$

for $i = d, f$. Because the rents given up to rm are costly for the regulators the participation constraint of the rm will be binding at the optimum of the program of each regulator. The rst-order conditions associated with the programs of regulator d and f are respectively:

$$\{ \, p_d(q_d) - \theta_d - 2q_d = (1+\delta)q_f p_f(q_f) - \theta_f - 2q_f = \frac{1+\delta}{\delta} q_d.$$

Solving simultaneously for these FOC, we get the full information outcome given by:

$$\{ \, q_d = \frac{\delta}{\Delta}[(2+b_f)(a_d-\theta_d)-(1+\delta)(a_f-\theta_f)] q_f = \frac{1}{\Delta}[\delta(2+b_d)(a_f-\theta_f)-(1+\delta)(a_d-\theta_d)] \tag{3}$$

[8] Thus in the paper we use the non-exclusion approach as in Ivaldi-Martimort (1996). This approach enables the possibility to have equilibria where the MNE produces in both or in one country, as opposed to the model of Biglaiser-Mezzetti (1993) where the rm is obliged to choose only one country to serve and the Martimort (1992) and Stole (1992) papers in which the agent (here the MNE) can only participate with both principals (the countries). On the difference between these settings see also Calzolari and Scarpa (1999).

where $\Delta = \delta(2 + b_d)(2 + b_f) - (1 + \delta)^2$. Even under complete information there is a strong tension between the two activities. Indeed, we have the following proposition:

Proposition 1 *Under complete information, there exists a unique Nash equilibrium of the game between the two regulators. This equilibrium is characterized by*

1. *If* $\min(\frac{1+\delta}{2+b_f}, \frac{\delta(2+b_d)}{1+\delta}) \leq \frac{a_d-\theta_d}{a_f-\theta_f} \leq \max(\frac{1+\delta}{2+b_f}, \frac{\delta(2+b_d)}{1+\delta})$ *then both quantities are positive and given by (3).*

2. *Otherwise, when* $\frac{1+\delta}{2+b_f} \leq \frac{\delta(2+b_d)}{1+\delta}$, *then*

   - *If* $\frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{1+\delta}{2+b_f}$, *then an asymmetric equilibrium prevails with*

   $$\{ q_d = 0 q_f = \frac{1}{2 + b_f}(a_f - \theta_f).$$

   - *If* $\frac{a_d-\theta_d}{a_f-\theta_f} \geq \frac{\delta(2+b_d)}{1+\delta}$, *then an asymmetric equilibrium prevails with*

   $$\{ q_d = \frac{1}{2 + b_d}(a_d - \theta_d) q_f = 0.$$

We encounter here a crucial idea that we will develop in the paper: Regulatory competition can lead to the exclusion of one regulator. We also want to emphasize that this result hinges on two facts. First, the rm only partially cares from the bene t earned in the foreign country. Second, there exists a non separability between the two goods in the cost function of the rm. Proposition 1 is very intuitive. The rst case tells us that when the spread between $a_d - \theta_d$ and $a_f - \theta_f$ is not too small, not too large (the good is equally worth for both regulators), then the game between regulators ends up with the rm producing for both countries. However, when the good is worth more to regulator f relatively to regulator d (rst part of case 2), then the tension becomes high for regulator d who gives up regulating the rm and shuts down production in its country. The analysis is reversed when the good is worth more to regulator d relatively to regulator f. Notice that the asymmetric equilibria arise only for values of δ which are not too low. The following picture illustrates these results.

Figure 1 here

4 Asymmetric Information Without Exclusion

In this section we ll characterize the equilibrium in which neither country is excluded from MNE s services. We shall show in particular that when we use the non exclusion approach, there exists an equilibrium with strictly positive quantities in both countries.

When dealing with regulators, given the transfers offered, the rm will choose simultaneously the quantities q_d and q_f in order to maximize its pro t function (1). Neglecting in a rst time the conditions ensuring the global concavity of this problem, the quantities chosen by the rm satisfy the following pair of rst-order conditions:

$$\begin{cases} 4\, q_d + (1+\delta) q_f = a_d - \theta_d - T'_d(q_d) \\ (1+\delta) q_d + 4\delta q_f = \delta(a_f - \theta_f) - \delta T'_f(q_f) \end{cases}$$

.

As pointed out in Ivaldi-Martimort (1996), this system is very complicated to deal with. However, we will show that there exists an equilibrium with quadratic tariffs[9]. The characterization of this particular equilibrium is achieved through several steps provided in the following subsections. The methodology we use is that of Ivaldi-Martimort (1996) which we adapt to our context.

4.1 Sufficient statistics and MNE s rent

Let us rst simplify the program of regulator R_f. We assume that regulator R_d offers a quadratic tariff $T_d(q_d) = \gamma_d + \alpha_d q_d + \frac{\beta_d}{2} q^2{}_d$. Then the above pair of FOC simplify to:

$$\begin{cases} (1+\delta) q_f + (4+\beta_d) q_d = a_d - \theta_d - \alpha_d \\ (1+\delta) q_d + 4\delta q_f = \delta(a_f - \theta_f) - \delta T'_f(q_f) \end{cases}$$

For the moment, we assume that it is optimal for the rm to produce positive outputs for both countries. Take the foc for output q_d and express q_d as a function of q_f. Substituting back into the foc for output q_f this becomes

[9] Notice that other equilibria could also exist.

$$\{ q_d = \frac{a_d - \theta_d - \alpha_d}{4 + \beta_d} - \frac{1+\delta}{4+\beta_d} q_f (4\delta - \frac{(1+\delta)^2}{4+\beta_d}) q_f - \frac{1+\delta}{4+\beta_d}\theta_d = \delta(a_f - \theta_f) - \frac{1+\delta}{4+\beta_d}(a_d - \alpha_d) - \delta T'_f \tag{4}$$

This first-order condition is equivalent to the one which would characterize the maximization program of a firm facing a single regulator R_f.

Moreover the asymmetry of information characterizing the relationship between a firm maximizing its profit and regulator R_f can be synthesized by the sufficient statistic

$$z_f = -\frac{1+\delta}{4+\beta_d}\theta_d$$

At the firm's level, z_f reflects one of the interactions between the regulators. Indeed, it is a sufficient statistic in the sense that not only it contains the private information of the firm but it also contains some parameters of the contract offered by the other regulator, i.e β_d. In fact, regulator d's parameter β_d affects z_f and when one regulator proposes a contract to the multinational, it affects the way the latter will decide the quantity to produce for the other regulator.

Regulators simultaneously offer contracts to the firm and we can perform a similar exercise for regulator R_d. In so doing, we find that the sufficient statistic in this case is

$$z_d = -\frac{1+\delta}{4+\beta_f}\theta_f$$

One point must be noticed. Let us consider regulator R_f. We have previously shown that it was only able to make the firm reveal z_f. One can ask wether upon the observation of the announcement of the z_f regulator R_f can infer some information on θ_d. The answer turns out to be negative. Indeed, for any announced value of z_f it is impossible to recover the value of θ_d as z_f depends on the parameter β_d which is not observed by R_f and can take any values in $]-\infty, +\infty[$. Hence, with an abuse of notations, we have $f_d(\theta_d/z_f) = f_d(\theta_d)$ where $f_d(\theta_d)$ is the prior of regulator R_f on θ_d (the posterior information is completely uninformative).

Now we shall rewrite the rent of the firm as a function of these new statistics. Let $\Pi_f(\theta_f, z_f) \equiv \pi(\theta_d, \theta_f) = \max_{q_d>0, q_f>0} \pi(q_d, q_f; \theta_d, \theta_f)$ denote the modified rent which regulator R_f has to face. This rewriting will have important implications for the analysis. Indeed, R_f will not be able to screen the rm along the θ_d-dimension as it cannot affect this part of the rm s rent by its regulation. Proceeding in a similar fashion, we denote by $\Pi_d(z_d, \theta_d) \equiv \pi(\theta_d, \theta_f)$ the rent of the rm depending on z_d and, again, R_d will not be able to screen the rm according to θ_f. Only the sufficient statistic z_d will be relevant for the analysis of R_d s problem.

4.2 MNE s Localization Decisions and the Participation Constraints

One of the advantages of the multinational is the possibility to decide to shut down production in one country while continuing to earn pro ts in the other one. This is a well known problem in globalized economies. We shall capture this phenomenon in the following way. First, each regulator must ensure that the global participation constraints (GPC) are satis ed to have the rm produce in both countries, that is,

$$(GPC) \quad \begin{cases} \Pi_f(\theta_f, z_f) \geq 0 \\ \Pi_d(z_d, \theta_d) \geq 0. \end{cases}$$

As coined by Bernheim and Whinston [1986], this is the usual participation constraints in an intrinsic common agency setting. However, as explained earlier, the multinational rm is able to threat one regulator to shut down production in its country and to produce only for the other one. We view this possibility as an important characteristic of the power of the multinational *vis à vis* the local regulators. It is then natural to de ne the outside opportunities of the rm as follows:

- with respect to regulator R_d this is the gain when the rm only produces in country f, or

  $$\omega_d(\theta_f) = \max_{q_f} \{\pi(\theta_d, \theta_f, q_d = 0, q_f)\}$$

  and simple computations give

  $$\omega_d(\theta_f) = -\delta\gamma_f + \frac{\delta(a_f - \theta_f - \alpha_f)^2}{2(4 + \beta_f.)}$$

[9] We use our assumption that regulators cannot condition their contracts on the decision of localization of the rm.

- With respect to regulator R_f this is the gain when the rm only produces in country d, or

$$\omega_f(\theta_d) = \max_{q_d} \{\pi(\theta_d, \theta_f, q_d, q_f = 0)\}$$

and simple computations give

$$\omega_f(\theta_d) = -\gamma_d + \frac{(a_d - \theta_d - \alpha_d)^2}{2(4+\beta_d)}$$

These notations enable us to introduce the no exclusion constraints.. In the case the multinational produces for country i, regulator j must be able to make the rm producing also for her own market j. Otherway stated, the rm should prefer to be active in both countries rather than producing for the only country i,

$$(NEC) \begin{cases} \Pi_f(\theta_d, z_f) \geq \omega_f(\theta_d) \\ \Pi_d(z_d, \theta_f) \geq \omega_d(\theta_f). \end{cases}$$

The no exclusion constraint stipulates that the gain of the rm when it takes both contracts is greater than the gain when it takes only the contract offered by the rival regulator. These constraints are particularly relevant for the analysis. In particular, we must check that in equilibrium all the optimal quantities are strictly positive in order to validate this approach. We will come back on this point later on.

Lemma 2 *If the NEC constraints are satis ed, then the GPC constraints are also satis ed.*

The lemma is proved by showing that both outside opportunities of the rm are strictly positive. Notice that this is not immediate because of the presence of the xed part of the quadratic transfers and the result mainly relies on the substitutability of the goods produced by the rms. With substitutability the threat to abandon one country is credible because the rm is able to reduce production cost with being active for one country only. Thus both countries are obliged to increase the rm s pro t in order to make it producing for their own markets. (On the contrary, with complementarity this threat would be non credible). The importance of this result is that it implies in particular the (NEC) constraints will be always more demanding than the (GPC) constraints.

As a consequence of this result, for the rest of the analysis we will skip the (GPC) conditions.

4.3 The modi ed problem

Before turning on to the regulators problem, let us introduce a last rewriting of the rent of the rm

$$\Pi_f(\theta_d, z_f) = \max_{q_d, q_f} \{(p_d(q_d) - \theta_d)q_d - q_d^2 - q_d q_f(1+\delta) - T_d(q_d)$$
$$+\delta[(p_f(q_f) - \theta_f)q_f - q_f^2 - T_f(q_f)]\}.$$

Using the de nitions of $\omega_f(\theta_d)$ and z_f and the fact that $q_d = \frac{a_d - \theta_d - \alpha_d}{4+\beta_d} - \frac{1+\delta}{4+\beta_d} q_f$ (from the FOC w.r.t q_d) we nd after some manipulations,

$$\Pi_f(\theta_d, z_f) = \omega_f(\theta_d) + \max_{q_f} \{(c_1(\theta_f) - z_f)q_f + c_2 q_f^2 - \delta T_f(q_f)\}$$

where $c_1(\theta_f) = \delta(a_f - \theta_f) - (1+\delta)\frac{a_d - \alpha_d}{4+\beta_d}$ and $c_2 = -2\delta + \frac{(1+\delta)^2}{2(4+\beta_d)}$.

This rewriting clearly show why regulator R_f cannot screen the rm according to θ_d. Indeed, we can see that when dealing with regulator f, the rm s choice about q_f is affected only by z_f and not directly by θ_d. Summarizing, the rm s pro t can be rewritten in a regulator-speci c way and then employed in the solution of the two regulation programs:

- For regulator R_f,

  $$\Pi_f(\theta_f, z_f) = \omega_f(\theta_d) + u_f(z_f)$$

  with $u_f(z_f) = \max_{q_f} \{(c_1^f(\theta_f) - z_f)q_f + c_2^f q_f^2 - \delta T_f(q_f)\}$, where $c_1^f = (\theta_f)\delta(a_f - \theta_f) - (1+\delta)\frac{a_d - \alpha_d}{4+\beta_d}$ and $c_2^f = -2\delta + \frac{(1+\delta)^2}{2(4+\beta_d)}$.

- For regulator R_d,

  $$\Pi_d(z_d, \theta_d) = \omega_d(\theta_f) + u_d(z_d)$$

  with $u_d(z_d) = \max_{q_d} \{(c_1^d(\theta_d) - z_d)q_d + c_2^d q_d^2 - T_d(q_d)\}$ where $c_1^d(\theta_d) = a_d - \theta_d - \frac{(1+\delta)(a_f - \alpha_f)}{4+\beta_f}$ and $c_2^d = -2 + \frac{(1+\delta)^2}{2\delta(4+\beta_f)}$.

Now everything is as if regulator i faces a rm with gross utility given by $u_i(z_i)$. This trick makes the problem easier to solve.

4.4 Resolution of the regulatory game and equilibrium allocations

First, recall that for regulator R_d (resp. R_f) there is no possibility to discriminate the rm according to θ_f (resp. θ_d). Hence, we will use the following version of the Revelation Principle: Any outcome that can be achieved by R_d (resp. R_f) under a mechanism $\{q_d(\tilde{z}_d, \tilde{\theta}_f), T_d(\tilde{z}_d, \tilde{\theta}_f)\}$ (resp. $\{q_f(\tilde{\theta}_d, \tilde{z}_f), T_f(\tilde{\theta}_d, \tilde{z}_f)\}$) which uses non informative message $\tilde{\theta}_f$ (resp. $\tilde{\theta}_d$) can be achieved with a simpler mechanism of the form $\{q_d(\tilde{z}_d), T_d(\tilde{z}_d)\}$ (resp. $\{q_f(\tilde{z}_f), T_f(\tilde{z}_f)\}$).

Given that any regulator i can only screen w.r.t. z_i, the only relevant part of pro t Π_i in the regulation-revelation phase is $u_i(z_i)$. Thus, for the participation constraints in regulator i s program we have the following equivalence

$$\begin{cases} \Pi_i(\theta_i, z_i) \geq 0 \\ \Pi_i(\theta_i, z_i) \geq \omega_i(\theta_j) \end{cases} \Leftrightarrow \begin{cases} u_i(z_i) \geq -\omega_i(\theta_j) \\ u_i(z_i) \geq 0 \end{cases}$$

with $i \neq j$. But, as we already showed $\omega_i(\theta_j) > 0$ and then only the constraint $u_i(z_i) \geq 0$ is relevant. Moreover, employing standard mechanism design techniques the incentive compatibility conditions considered by regulator i are

$$\dot{u}_i(z_i) = -q_i(z_i) \text{ and } \dot{q}_i \leq 0.$$

The program of regulator R_i can then be stated as follows:

$$(PR_i) \begin{cases} \max\limits_{q_i(.)} \mathbf{E}_{z_i} \mathbf{E}_{\theta_j} \{ \int_0^{q_i} p_i(x)dx - p_i(q_i)q_i + \frac{1}{1+(\delta-1)\mathcal{I}(i)} [(c_1^i - z_i)q_i + c_2^i q_i^2 - u_i(z_i)] \} \\ \text{s.t.} \\ \dot{u}_i(z_i) = -q_i(z_i) \\ \dot{q}_i(z_i) \leq 0 \\ u_i(z_i) \geq 0 \forall z_i \end{cases}$$

where $\mathcal{I}(i) = \begin{cases} 1 & \text{if} \quad i = f \\ 0 & \text{if} \quad i = d \end{cases}$. The solution to this program provides necessary conditions for the equilibrium:

$$q_i(z_i) = \frac{-1}{1 + (\delta - 1)\mathcal{I}(i) + 2c_2^i} [\mathbf{E}_{\theta j}(c_1^i) - z_i - \frac{F(z_i)}{f(z_i)}] \tag{5}$$

with $i, j = d, f$ and $i \neq j$.

As is clear from the expressions, the quantities in one country depend on the parameters of the quadratic transfer used by the regulator of the other country (through c_1^i and c_2^i).

It now remains a last step. It consists in recovering the parameters of the quadratic transfer offered by regulator R_f, making use of the following identity:

$$\begin{aligned} u_f(z_f) &= (c_1 - z_f)q_f + c_2 q_f^2 - \delta T_f(q_f) \\ &= \int_{z_f}^{\overline{z}_f} q_f(x)dx \end{aligned}$$

Lemma 3 *There exists an equilibrium in quadratic tariffs, provided the distribution of the* z_i *have linear hazard rate.*

Hence, because the distribution (which is uniform) of z_f has a linear hazard rate on its support $[\underline{z}_f, \overline{z}_f]$ then the optimal quantity q_f will be linear in z_f and the optimal non linear transfer $T_f(q_f)$ will be quadratic in q_f.

We can nally solve for the Nash equilibrium in quantities

Proposition 4 *In the no exclusion regime, the Nash equilibrium of the game between regulators is the following:*

$$\begin{aligned} q_d &= \frac{\delta}{D}[(4\delta - 2k^2)a_d - (4\delta - k^2)\theta_d - 2\delta k a_f + 2k(4\delta - k^2)\theta_f + k(2k^2 + \frac{3}{2}k - 5\delta)] \\ q_f &= \frac{1}{D}[\delta(4\delta - 2k^2)a_f - \delta(4\delta - k^2)\theta_f - 2\delta k a_d + 2k(4\delta - k^2)\theta_d + k(2k^2 + \frac{3}{2}\delta k - 5\delta)] \end{aligned}$$

where $k = \frac{1+\delta}{4+\beta_d} = \frac{1+\delta}{4+\beta_f}$ *and* $D = (4\delta - k^2)(3\delta - k - k\delta)$.

It is important to note that the second order conditions for implementability for both regulators are satis ed only for values of δ greater than 0.145. Therefore, in the analysis of the equilibrium quantities as well as in the comparative statics, unless precised, we ll implicitly assume that $\delta \in [0.145, 1]$.

4.5 Comparative statics

First, for any $\delta \in]0,1]$, the terms k, $4\delta - 2k^2$ and $4\delta - k^2$ are strictly positive. D is positive. Subsequently q_i is increasing in a_i and θ_j, decreasing in a_j and θ_i where $i,j = d,f; i \neq j$. This means that when the Mne have a substantial ownership share in the subsidiary, then it will sell more output in one country the higher the market size in this country, and less the higher the market size in the other country. Also, the equilibrium pro le is such that a local increase in production efficiency increases local production while it decreases foreign production. Everything being equal, an increase in a_d and a_f of the same unit will increase q_d. This means that in this case the market size has more weight in country d than in country f. For q_f, the effect of an equal increase in a_d and a_f has a less radical effect. Indeed, for $\delta \leq 0.5$, this will cause q_f to decrease, while it increases for $\delta \geq 0.5$. In other words, i n country f, the market size is not a strong incentive to increase production as long as the part δ of the revenues earned by the Mne in this country is not substantial enough. Therefore, one of the lessons we can learn from our model is the following: when a Mne sees his market size increasing (equally) in the countries where he is located, regulators of the subsidiaries should ensure that the Mne owns a relatively high share in the subsidiary they are regulating. This prediction is somewhat intuitive because one can think that the country where the Mne have a greater ownership will always be wining more. What is more interesting is this cutoff value of 0.5 which clearly call for a majority in ownership.

Everything being equal, the same increase in θ_d and θ_f will increase q_f. This is to say that when the two divisions lose equally in efficiency, the country where the Mne has a lower share will see its production increase. This is probably because it attach less importance to the pro t in that country, the losses due to increases in costs are less harmful.. The effect on q_d is that it decreases as long as $0.145 \leq \delta \leq 0.296$ and increases when $\delta \geq 0.296$. The reason is that for δ small enough, as previously explained, the Mne will cut the costs by producing less in the country where it has full ownership (and therefore full revenues) and produce more in the foreign country where the impact of the efficiency loss is less important. The following gure summarizes some of these results.

Figure 2 here

5 Asymmetric Equilibria

So far we have focused our attention on equilibria with strictly positive productions in both countries. Indeed, in order to compute the outside opportunity of the rm vis à vis one given regulator, we implicitly assumed that, in equilibrium, the rm will be active in both countries.

However it appeared clearly, even under complete information, that for some parameters values asymmetric equilibria could emerge as the outcome of this game. The goal of this section is to study how asymmetric information modi es the zones of parameters values in which those asymmetric equilibria could emerge.

We decompose this study into two parts. First we look for standard exclusion equilibria which arise when the quantity pro le of one regulator is negative in equilibrium. Second, we show that one given regulator can use sophisticated (in a sense to be de ned later on) indirect mechanism in order to attract the rm in its country and to exclude the rival regulatory agency. We call this the voluntary exclusion case.

5.1 Intrinsic Exclusion

We proceed in the following way. First, we assume that one regulator, say R_d, decides to shut down the production of the multinational in his country: $q_d = 0$. The pro t of the rm is now given by

$$\pi_{df} = \delta[(p_f(q_f) - \theta_f)q_f - q_f^2 - T_f(q_f)]$$

Now, from our informational assumptions, regulator R_f is under complete information vis à vis the rm! This leads him to implement the full information quantity (with $q_d = 0$) given by

$$q_f^* = \frac{1}{3}(a_f - \theta_f)$$

The next step consists in recovering the parameters of the transfer used by R_f to implement this quantity. It is by now a standard result in incentive theory that under complete information a *linear* transfer is enough to implement the full information allocation. Henceforth, with our notations, these parameters must be such that

- $\pi_{df}(q_f^*) = 0$

- $\frac{\partial \pi_{df}}{\partial q_f}(q_f^*) = 0$ (and $\frac{\partial^2 \pi_{df}}{\partial q_f^2}(q_f^*) \leq 0$)

The rst condition states that R_f leaves no rent to the rm. The last conditions ensure that it is optimal for the rm to produce q_f^*. Once again, because R_f regulates the rm under complete information, a linear transfer $T_f(q_f) = \gamma_f^{e,d} + \alpha_f^{e,d} q_f$ is enough.

Now we can use the set of identi cation equations (IE) determined in the general case to nd the best response of R_d when R_f proposes the linear transfer with parameters $(\gamma_f^{e,d}, \alpha_f^{e,d})$ to the rm. This nally enables us to nd the optimal quantity pro le q_d offered in equilibrium by R_d, and the conditions such that these quantities are negative (for all parameters values). This validates our approach. Of course, these computations can be done in turn for R_d instead of R_f. The results are gathered in the next proposition.

Proposition 5 *Assume that* $3\delta \geq (\frac{1+\delta}{2})^2$. *Asymmetric equilibria can emerge under the following conditions:*

- *If* $3a_d - (1+\delta)a_f \leq -\frac{7}{4}\frac{1+\delta}{2}$ *then* R_d *is excluded:* $q_d = 0$ *and* $q_f = \frac{1}{3}(a_f - \theta_f)$.
- *If* $3\delta a_f - (1+\delta)a_d \leq -\frac{7}{4}\frac{1+\delta}{2}$ *then* R_f *is excluded:* $q_f = 0$ *and* $q_d = \frac{1}{3}(a_d - \theta_d)$.

One can see that those simple asymmetric equilibria emerge when the difference between the market sizes is sufficiently large. This con rms our ndings in the case of complete information.

Figure 3 here

Indeed, under full information, an asymmetric equilibrium with $q_d = 0$ prevails for all the costs parameters of the rm if $3a_d - (1+\delta)a_f \leq -(1+\delta)$. But the important point to notice is that under incomplete information the condition for these equilibria to emerge becomes much more demanding: The zone of parameters values in which regulator R_d is excluded shrinks when the information is no longer complete! To summarize,

Proposition 6 *Asymmetric information softens the regulatory competition.*

Last, notice that the condition $3\delta \geq (\frac{1+\delta}{2})^2$ is made to ensure that the program of the excluded regulator is concave. However, in the general case, the second order condition of the maximization problem of one regulator (i.e. the second order condition for implementability) depends endogenously on the contract proposed by the rival regulator. In the next subsection, we show that with a judicious choice of the non linear transfer offered to the rm one regulator can enlarge the zone of parameters values in which asymmetric equilibria can emerge.

5.2 Attractive Regulation and Voluntary Exclusion

In this subsection, we show that one regulator can exclude his rival by playing on the quadratic part of the transfer, i.e. the curvature of the contract, he offers to the rm. Indeed, the quadratic term is crucial because it affects the way the rm will reveal its information to the rival regulator.

First, as in the previous subsection, let us assume that $q_d = 0$. Then R_f wants to implement $q_f^* = \frac{1}{3}(a_f - \theta_f)$. However, we consider now that R_f uses a quadratic instead of a linear transfer (which would be enough): $T_f(q_f) = \gamma_f + \alpha_f q_f + \frac{1}{2}\beta_f q_f^2$. This new parameter is only restrained to satisfy $\frac{\partial^2 \pi_{df}}{\partial q_f^2}(q_f^*) \leq 0$ or $4 + \beta_f \geq 0$. Then, for the rest of this subsection we assume that $\beta_f \in]-4, +\infty[$. When R_f uses this transfer the second order condition for implementability (the so called Spence Mirrlees condition) for R_d is

$$1 + 2c_2' \leq 0 \Leftrightarrow 3\delta(4 + \beta_f^{e,d}) \geq (1 + \delta)^2$$

In the general analysis this condition has to be checked ex post in equilibrium. However, here this condition for R_d depends endogenously on a *free* parameter at the disposal of R_f. Hence there are two ways for R_f to try to exclude its rival:

- Either $\beta_f^{e,d}$ is chosen such that the second order condition for implementability of R_d is satis ed ; Then R_d will be effectively excluded if its equilibrium quantity pro le (which is perfectly screening) is negative for all type of rm (i.e. for all z_d).
- Or $\beta_f^{e,d}$ is such that the second order condition for implementability is not satis ed ; R_d is then forced to offer a pooling contract. Exclusion occurs then if this unique equilibrium quantity is negative.

In both cases, the curvature of the transfer will chosen so as to render the zone of parameters values satisfying the exclusion condition as large as possible. As previously, those computations can be done in turn for the case of exclusion of R_f. These standard computations are relegated in appendices and we summarize our results in the next proposition.

Proposition 7 *1. If either* $3a_d - (1+\delta)a_f \leq -\frac{1+\delta}{2}$ *or* $3a_d - (1+\delta)a_f \geq \frac{9\delta-(1+\delta)^2}{2(1+\delta)} + 3$ *then with an appropriate choice of the quadratic part of its transfer regulator* R_f *can force regulator* R_d *to shut down production in its country.*

2. If either $3\delta a_f - (1+\delta)a_d \leq -\frac{1+\delta}{2}$ *or* $3\delta a_f - (1+\delta)a_d \geq \frac{9\delta-(1+\delta)^2}{2(1+\delta)} + 3\delta$ *then with an appropriate choice of the quadratic part of its transfer regulator* R_d *can force regulator* R_f *to shut down production in its country.*

Hence, a regulator who wants to exclude its rival will certainly prefer to use a sophisticated mechanism instead of relying on a simple linear transfer. One can also interpret the curvature of the transfer as the degree of attractiveness of the regulatory policy offered by one regulator to the multinational. Depending on the parameters values, that is depending on how one regulator will exclude its rival, the curvature is set at different values.

Figure 4 here

Finally, notice that playing on the curvature of the transfer to exclude the rival regulator would no longer be possible were both regulator under asymmetric information with respect to both costs characteristics. However, we think that this result is clearly illustrative of the game that sometimes takes place between rival countries to attract one multinational.

6 Conclusions

In this paper we have analyzed a regulation model in an international setting. National regulators deal with a multinational rm which may decide to produce for all or some of them. We have considered the realistic case in which national regulators have a comparative advantage with respect to foreign one in the Mne s information: local regulators are better informed than foreign ones on local production activities.. Beside being a technical improvement in the common agency literature, our model shows that information comparative advantage of local regulators implies ercer competition among regulators. We have shown that when the Mne s ownership in one subsidiary is sufficiently small, then only equilibria with exclusion arise in which the rm serves one market (implicit exclusion). Moreover, national regulators may voluntary end up in such equilibria with designing appropriate regulatory mechanisms (voluntary exclusion).

In this paper the two pieces of private information the Mne owns are uncorrelated. An interesting extension is to study the present framework with intermediate correlation among information such that the two extreme cases, no correlation and perfect correlation, would respectively correspond to the setting of this paper and the one employed in the existing literature on common agency.

In a companion paper we are analyzing the case of competition in generic transfers. Preliminary results show that the assumption of linear-quadratic transfers of this paper can be eliminated without modifying the main results and intuitions of the present paper.

7 Appendices

7.1 Proof of Proposition 1

Part 1: The outcome given by system (1) will be an equilibrium if both q_d and q_f are positive. This will be the case if

- either $\Delta \geq 0$ and $\frac{a_d-\theta_d}{a_f-\theta_f} \geq \frac{1+\delta}{2+b_f}$ and $\frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{\delta(2+b_d)}{1+\delta}$. Those conditions are trivially equivalent to

$$\frac{1+\delta}{2+b_f} \leq \frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{\delta(2+b_d)}{1+\delta},$$

- or $\Delta \leq 0$ and $\frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{1+\delta}{2+b_f}$ and $\frac{a_d-\theta_d}{a_f-\theta_f} \geq \frac{\delta(2+b_d)}{1+\delta}$, conditions which summarize as

$$\frac{\delta(2+b_d)}{1+\delta} \leq \frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{1+\delta}{2+b_f}.$$

Taking together the two inequalities, we get part 1 of the proposition.

Part 2: we nd the asymmetric equilibria by contradiction. First equilibrium: Assume $q_d = 0$. Then $\pi_{df} = [p_f(q_f) - \theta_f]q_f - q_f^2 - T_f(q_f)$. Solving for the program of regulator f, we get that $q_f = \frac{a_f-\theta_f}{2+b_f}$. We now substitute this quantity in the F.O.C of the initial program of regulator d (the program without constraints on q_d). We then get

$$q_d = \frac{1}{2+b_d}[a_d - \theta_d - \frac{1+\delta}{2+b_f}(a_f - \theta_f)].$$

If $q_d \leq 0$, then the hypothesis we started with will turn out to be true. From the above equation, it is clear that this will be the case if $\frac{a_d-\theta_d}{a_f-\theta_f} \leq \frac{1+\delta}{2+b_f}$. Now it just remain to ensure that this condition violates the one for symmetric equilibrium of part1, it indeed does it if $\frac{1+\delta}{2+b_f} = min(\frac{1+\delta}{2+b_f}, \frac{\delta(2+b_d)}{1+\delta})$. This ends the characterization of this rst asymmetric equilibrium. The second asymmetric equilibrium is obtained in a similar way. QED

7.2 Global Concavity of the Firm s Problem

The Hessian of the maximization problem of the MNE must be semi de nite negative. This is equivalent to the following conditions:

$$\begin{aligned} 4+\beta_i &\geq 0 \quad i=d,f \\ \delta(4+\beta_d)(4+\beta_f)-(1+\delta)^2 &\geq 0 \end{aligned}$$

7.3 Proof of Lemma 1

Let us consider rst the problem of regulator f. We shall show that $\omega_f(\theta_d) \geq 0$. The program of the other regulator, i.e R_d is such that the no exclusion constraint for a rm with private characteristics $(\theta_d, \underline{\theta}_f)$ is binding, i.e

$$\max_{q_d>0,q_f>0}\{\pi(\theta_d,\underline{\theta}_f,q_d,q_f)-T_d(q_d)-\delta T_f(q_f)\} = \max_{q_f}\{\pi(\theta_d,\underline{\theta}_f,q_d=0,q_f)-\delta T_f(q_f).\}$$

Hence,

$$\begin{aligned} \gamma_d = &\max_{q_d>0,q_f>0}\{\pi(\theta_d,\underline{\theta}_f,q_d,q_f)-\alpha_d q_d-\frac{1}{2}\beta_d q_d^2-\delta T_f(q_f)\}- \\ &-\max_{q_f}\{\pi(\theta_d,\underline{\theta}_f,q_d=0,q_f)-\delta T_f(q_f).\} \end{aligned}$$

But, by de nition we also have $\omega_f(\theta_d) = -\gamma_d + \frac{(a_d-\theta_d-\alpha_d)^2}{2(4+\beta_d)}$. Hence condition $\omega_f(\theta_d) > 0$ turns out to be equivalent to

$$\begin{aligned} \max_{q_f}\{\pi(\theta_d,\underline{\theta}_f,q_d &= 0,q_f)-\delta T_f(q_f)\}+\frac{(a_d-\theta_d-\alpha_d)^2}{2(4+\beta_d)} \\ &> \max_{q_d>0,q_f>0}\{\pi(\theta_d,\underline{\theta}_f,q_d,q_f)-\alpha_d q_d-\frac{1}{2}\beta_d q_d^2-\delta T_f(q_f)\} \end{aligned}$$

or (subtracting γ_d on both sides),

$$\max_{q_d>0,q_f>0}\{\pi_d(\theta_d,q_d)+\pi_f(\theta_f,q_f)\} > \max_{q_d>0,q_f>0}\{\pi_d(\theta_d,q_d)+\pi_f(\theta_f,q_f)-(1+\delta)q_d q_f\}$$

Denote by (q_d^*, q_f^*) the optimal values of the maximization problem in the left hand side and (q_d^{**}, q_f^{**}) the optimal values of the maximization problem in the right hand side of the inequality. Obviously we have $q_d^* > q_d^{**}$ and $q_f^* > q_f^{**}$. Because the maximand of each terms are increasing and concave then the value function of the program in the left hand side of the inequality is greater than the one in the right hand side. Hence the result. Note nally that we have assumed in all the previous demonstrations that all the quantities produced were strictly positive. We must check this in equilibrium.

7.4 Resolution of R_i s Problem

The welfare in country i is given by

$$\begin{aligned} SW_i &= \int_0^{q_i} p_i(x)dx - p_i(q_i)q_i + T_i(q_i) \\ &= \int_0^{qi} p_i(x)dx - p_i(q_i)q_i + \frac{1}{1+(\delta-1)\mathcal{I}(i)}\left[(c_1^i - z_f)q_f + c_2^i q_f^2 - u_f(z_f)\right] \end{aligned}$$

where $\mathcal{I}(i) = \begin{cases} 1 & \text{if} \quad i = f \\ 0 & \text{if} \quad i = d \end{cases}$. The Hamiltonian associated to the program (PR_i) is

$$\begin{aligned} H[u_i, q_i, z_i] &= \mathbf{E}_{\theta_j}[f(z_i)\{\int_0^{q_i} p_i(x)dx - p_i(q_i)q_i \\ &\quad + \frac{1}{1+(\delta-1)\mathcal{I}(i)}[(c_1^i - z_i)q_i + c_2^i q_i^2 - u_i(z_i)]\}] - \eta(z_i)q_i(z_i) \end{aligned}$$

First note that the Hamiltonian is concave in (q_i, u_i) if $1+\frac{2c_2^i}{1+(\delta-1)\mathcal{I}(i)} \leq 0$, a sufficient condition that we will check ex post thus ensuring that the second-order condition for implementability is satis ed. Applying the Maximum Principle and the fact that there is no transversality condition in $\underline{z}_i = z_i(\underline{\theta}_j)$, we obtain $\eta(z_i) = \frac{1}{1+(\delta-1)\mathcal{I}(i)}F(z_i)$. Optimizing then with respect to $q_i(z_i)$, we get

$$q_i(z_i) = \mathbf{E}_{\theta_j}\frac{-1}{1+(\delta-1)\mathcal{I}(i)+2c_2^i}[c_1^i - z_i - \frac{F(z_i)}{f(z_i)}]$$

7.5 Proof of lemma 2

We will prove the lemma only for regulator R_f. For regulator R_d, it is similar. We assume that θ_d and θ_f are uniformly distributed on $(0, 1)$. With this new speci cation,

$$\begin{aligned} q_f(z_f) &= \frac{-1}{\delta + 2c_2^f}[\mathbf{E}_{\theta_d}(c_1^f) - z_f - z_f + \underline{z}_f] \\ &\Leftrightarrow \;\; z_f = \frac{1}{2}[(\delta + 2c_2^f)q_f(z_f) + \mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f] \end{aligned}$$

Using the incentive compatibility constraint, we can write the rent of the rm

$$\begin{aligned} u_f(z_f) &= \int_{z_f}^{\overline{z}_f} \dot{u}_f(x)dx \\ &= -\int_{z_f}^{\overline{z}_f} q_f(x)dx \\ &= -\int_{z_f}^{\overline{z}_f} \frac{-1}{\delta + 2c_2^f}[\mathbf{E}_{\theta_d} c_1^f - 2z_f + \underline{z}_f] \\ &= \frac{z_f}{\delta + 2c_2^f}[\mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f - 2z_f] \end{aligned}$$

We now substitute the value of z_f

$$\begin{aligned} u_f(z_f) &= \frac{-1}{4(\delta + 2c_2^f)}[(\delta + 2c_2^f)q_f + \mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f][(\delta + 2c_2^f)q_f - \mathbf{E}_{\theta_d}(c_1^f) - \underline{z}_f] \\ &= \frac{-1}{4(\delta + 2c_2^f)}[(\delta + 2c_2^f)^2 q_f^2 - (\mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f)^2]. \end{aligned}$$

But we also know that

$$\begin{aligned} u_f(z_f) &= (c_1^f(\theta_f) - z_f)q_f + c_2^f q_f^2 - \delta T_f(q_f) \\ &\Leftrightarrow \;\; \delta T_f(q_f) = (c_1^f(\theta_f) - z_f)q_f + c_2^f q_f^2 - u_f(z_f). \end{aligned}$$

Substituting once again z_f and replacing $u_f(z_f)$ by the expression we got above, it comes

$$\begin{aligned} \delta T_f(q_f) &= \frac{1}{2}[2c_1^f - (\delta + 2c_2^f)q_f - \mathbf{E}_{\theta_d}(c_1^f) - \underline{z}_f] + c_2^f q_f^2 \\ &\quad + \frac{1}{4(\delta + 2c_2^f)}[(\delta + 2c_2^f)^2 q_f^2 - (\mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f)^2] \end{aligned}$$

or, nally

$$\delta T_f(q_f) = \frac{(\mathbf{E}_{\theta_d}(c_1^f) + \underline{z}_f)^2}{4(\delta + 2c_2^f)} + \frac{1}{2}(2c_1^f - \mathbf{E}_{\theta_d}(c_1^f) - \underline{z}_f)q_f - \frac{1}{4}(\delta - 2c_2^f)q_f^2.$$

We see that indeed, the mechanism of regulator R_f is quadratic. Identifying with $T_f(q_f) = \gamma_f + \alpha_f q_f + \frac{\beta_f}{2} q_f^2$, it is immediate that

$$\begin{aligned} \delta\beta_f &= c_2 - \frac{\delta}{2} \\ \delta\alpha_f &= c_1(\theta_f) - \frac{1}{2}\mathbf{E}_{\theta_d}\{c_1(\theta_f) + \underline{z}_f\} \\ \delta\gamma_f &= \frac{-1}{4(\delta + 2c_2)}[\mathbf{E}_{\theta_d}\{c_1 + \underline{z}_f\}]^2 \end{aligned}$$

Performing similar computations for regulator R_d, we get

$$\begin{aligned} \beta_d &= c_2'(\theta_d) - \frac{1}{2} \\ \alpha_d &= c_1'(\theta_d) - \frac{1}{2}\mathbf{E}_{\theta_f}\{c_1'(\theta_d) + \underline{z}_d\} \\ \gamma_d &= \frac{-1}{4(1 + 2c_2')}[\mathbf{E}_{\theta_f}\{c_1'(\theta_d) + \underline{z}_d\}]^2 \end{aligned}$$

As neither c_2 nor c_2' depend on θ_f or θ_d, one can solve directly for (β_f, β_d). Immediate computations yield (where we selected the couple of solutions that satisfy the second-order conditions for implementability of the rm):

$$\beta_f = \beta_d = \frac{-13\sqrt{\delta} + \sqrt{8 + 25\delta + 8\delta^2}}{4\sqrt{\delta}}$$

7.6 Equilibrium quantities

In order to compute the equilibrium quantities we must determine the equilibrium values of $\mathbf{E}_{\theta_f}(c_1^d)$ and $\mathbf{E}_{\theta_f}(c_1^f)$. Recall that

$$c_1^f(\theta_f) = \delta(a_f - \theta_f) - (1 + \delta)\frac{a_d - \alpha_d}{4 + \beta_d}$$

and

$$c_1^d(\theta_d) = a_d - \theta_d - \frac{(1 + \delta)(a_f - \alpha_f)}{4 + \beta_f}$$

It is straightforward to see that we therefore need to compute $\mathbf{E}_{\theta_f}\alpha_f$ and $\mathbf{E}_{\theta_d}\alpha_d$. Taking expectations over θ_d and θ_f in the two equations involving α_f and α_d, we have that:

$$\{ \delta\ \mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}\alpha_f = \mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}c_1^d - \frac{1}{2}\mathbf{E}_{\theta_f}\mathbf{E}_{\theta_d}(c_1^d + \underline{z}_f)\mathbf{E}_{\theta_f}\mathbf{E}_{\theta_d}\alpha_d = \mathbf{E}_{\theta_f}\mathbf{E}_{\theta_d}c_1^f - \frac{1}{2}\mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}(c_1^f + \underline{z}_d)$$

Since each regulator is locally informed, it is obvious that $\mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}\alpha_f = \mathbf{E}_{\theta_f}\alpha_f$ and $\mathbf{E}_{\theta_f}\mathbf{E}_{\theta_d}\alpha_d = \mathbf{E}_{\theta_d}\alpha_d$. Also, remember that $z_d = -\frac{1+\delta}{4+\beta_f}\theta_f$ and $z_f = -\frac{1+\delta}{4+\beta_d}\theta_d$. The above system is equivalent to

$$\{ \delta\ \mathbf{E}_{\theta_f}\alpha_f = \frac{1}{2}\mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}c_1^d + \frac{1}{2}\frac{1+\delta}{4+\beta_d}\mathbf{E}_{\theta_d}\alpha_d = \mathbf{E}_{\theta_d}\mathbf{E}_{\theta_f}c_1^f + \frac{1}{2}\frac{1+\delta}{4+\beta_f}$$

$$\Leftrightarrow \{ 2\ \delta\mathbf{E}_{\theta_f}\alpha_f = \delta(a_f - \frac{1}{2}) - \frac{(1+\delta)(a_d - \mathbf{E}_{\theta_d}\alpha_d)}{4+\beta_d} + \frac{1+\delta}{4+\beta_d}2\mathbf{E}_{\theta_d}\alpha_d = a_d - \frac{1}{2} - \frac{(1+\delta)(a_f - \mathbf{E}_{\theta_f}\alpha}{4+\beta_f}$$

$$\Leftrightarrow \{ 2\ \delta\mathbf{E}_{\theta_f}\alpha_f - k\mathbf{E}_{\theta_d}\alpha_d = \delta(a_f - \frac{1}{2}) - ka_d + k2\mathbf{E}_{\theta_d}\alpha_d - k\mathbf{E}_{\theta_f}\alpha_f = (a_d - \frac{1}{2}) - ka_f + k$$

where $k = \frac{1+\delta}{4+\beta_d} = \frac{1+\delta}{4+\beta_f}$.
Solving this system yields immediately:

$$\begin{aligned}
\mathbf{E}_{\theta_d}\alpha_d &= \frac{1}{4\delta - k^2}[-ka_d + (2\delta - k^2)a_f + k^2 + \frac{3}{2}k - \delta] \\
\mathbf{E}_{\theta_f}\alpha_f &= \frac{1}{4\delta - k^2}[(2\delta - k^2)a_d - k\delta a_f + k^2 + \frac{3}{2}\delta k - \delta]
\end{aligned}$$

Now we can compute the optimal quantities:

$$\begin{aligned}
q_d(z_d) &= \frac{\delta}{D}[(4\delta - 2k^2)a_d - (4\delta - k^2)\theta_d - 2\delta k a_f - 2(4\delta - k^2)z_d + k(2k^2 + \frac{3}{2}k - 5\delta)] \\
q_f(z_f) &= \frac{1}{D}[\delta(4\delta - 2k^2)a_f - \delta(4\delta - k^2)\theta_f - 2\delta k a_d - 2(4\delta - k^2)z_f + k(2k^2 + \frac{3}{2}\delta k - 5\delta)]
\end{aligned}$$

where $D = (4\delta - k^2)(3\delta - k - k\delta)$.

7.7 Asymmetric Equilibria

7.7.1 Exclusion of R_d

Assume rst that $1 + 2c_2' \leq 0 \Leftrightarrow 4 + \beta_f \geq \frac{(1+\delta)^2}{3\delta}$. Then R_d will try to implement the following quantity pro le:

$$q_d(z_d) = \frac{-1}{1 + 2c_2'}\mathbf{E}_{\theta_f}\{c_1'(\theta_d) - 2z_d + \underline{z}_d\}$$

These quantities are negative for every type of rm if

$$\mathbf{E}_{\theta_f}\{c_1'(\theta_d)\} - 2z_d + \underline{z}_d \leq 0 \quad \forall(z_d, \theta_d)$$

or

$$a_d - \frac{1+\delta}{4+\beta_f}[a_f - \mathbf{E}_{\theta_f}\alpha_f] \leq \underline{z}_d$$

Immediate computations show that to implement the full information quantity pro le $q_f^* = -\frac{1}{3}(a_f - \theta_f)$ R_f will use a transfer such that $\alpha_f = -\frac{1}{3}(1 + \beta_f)(a_f - \theta_f)$. Then the previous inequality becomes

$$(4 + \beta_f)[3a_d - (1+\delta)(a_f - \frac{1}{2}] \leq -\frac{3}{2}(1+\delta)$$

If the left hand side is positive then this inequality is never satis ed. Otherwise the left hand side is the smallest when β_f is chosen large. Then the inequality will be always satis ed with an appropriate choice of β_f when

$$3a_d - (1+\delta)a_f \leq -\frac{1+\delta}{2}$$

Notice that the condition for intrinsic exclusion is obtained by doing the same computations with $\beta_f = 0$.

Assume now that $1 + 2c_2' > 0 \Leftrightarrow 4 + \beta_f < \frac{(1+\delta)^2}{3\delta}$. Then R_d is forced to offer a pooling contract to the rm. Its program is

$$\{\ \overline{q}_d \max \mathbf{E}_{\theta_f}\{\int_0^{\overline{q}_d} p_d(x)dx - p_d(\overline{q}_d)\overline{q}_d + T_d(\overline{q}_d)\}(c_1'(\theta_d) - \overline{z})\overline{q}_d + c_2'\overline{q}_d^2 - T_d(\overline{q}_d) \geq 0$$

We assumed implicitly that R_d always wants to make every type of rm produce. The constraint will be binding at the optimum. Substituting $T_d(\overline{q}_d)$ and optimizing w.r.t. $\overline{q}_d$ we nd

$$\overline{q}_d = \frac{-1}{1 + 2c_2'}\mathbf{E}_{\theta_f}\{c_1'(\theta_d) - \overline{z}_d\}$$

Exclusion will occur if

$$\mathbf{E}_{\theta_f}\{c_1'(\theta_d)\} - \overline{z}_d \geq 0 \quad \forall \theta_d$$

or

$$\frac{4+\beta_f}{3(1+\delta)}\{3(a_d-1)-(1+\delta)(a_f-\frac{1}{2})\} \geq \frac{1}{2}$$

If the left hand side is negative then this inequality never holds. Otherwise β_f is chosen at its maximal value and the inequality oils down to

$$3a_d - (1+\delta)a_f \geq \frac{9\delta-(1+\delta)^2}{2(1+\delta)} + 3$$

7.7.2 Exclusion of R_f

Assume rst that $q_f = 0$. The pro t function of the rm is now

$$\pi_{df}(q_d) = (p_d(q_d) - \theta_d)q_d - q_d^2 - T_d(q_d)$$

Immediate manipulations show that R_d will implement the full information quantity given by

$$q_d^* = \frac{1}{3}(a_d - \theta_d)$$

The parameters $(\gamma_d, \alpha_d, \beta_d)$ of $T_d(q_d)$ are designed in such a way that $\alpha_d = -\frac{1}{3}(1+\beta_d)(a_d-\theta_d)$ and $4+\beta_d \geq 0$. Now let us assume that $\delta + 2c_2 \leq 0$ or $3\delta \geq \frac{(1+\delta)^2}{4+\beta_d}$. Then R_f will implement the following quantity pro le

$$q_f(z_f) = \frac{-1}{\delta+2c_2}\mathbf{E}_{\theta_d}\{c_1(\theta_f) - 2z_f + \underline{z}_f\}$$

Under our assumptions, these quantities are negative for all type of rm if

$$\mathbf{E}_{\theta_d}\{c_1(\theta_f)\} - 2z_f + \underline{z}_f \leq 0 \quad \forall (z_d, \theta_f)$$

or

$$(4+\beta_d)[3\delta a_f - (1+\delta)(a_d - \frac{1}{2})] \leq -\frac{3}{2}(1+\delta)$$

If the left hand side is negative then this inequality never holds. Otherwise β_d is chosen at its maximal value and the inequality boils down to

$$3\delta a_f - (1+\delta)a_d \leq -\frac{1+\delta}{2}$$

Assume now that $\delta + 2c_2 > 0$ or $4 + \beta_d < \frac{(1+\delta)^2}{3\delta}$. Then R_f is forced to offer a pooling contract and solves the following problem

$$\{ \overline{q}_f \max \mathbf{E}_{\theta_d} \{ \int_0^{\overline{q}_f} p_f(x)dx - p_f(\overline{q}_f)\overline{q}_f + T_f(\overline{q}_f)\} \text{subject to } (c_1(\theta_f) - \overline{z}_f)\overline{q}_f + c_2\overline{q}_f^2 - \delta T_f(\overline{q}_f) \geq 0$$

The solution is obviously given by

$$\overline{q}_f = \frac{-1}{\delta + 2c_2}\mathbf{E}_{\theta_d}\{c_1(\theta_f) - \overline{z}_f\}$$

Exclusion will occur if

$$\mathbf{E}_{\theta_d}\{c_1(\theta_f)\} - \overline{z}_f \geq 0 \quad \forall \theta_f$$

or

$$(4 + \beta_d)[3\delta(a_f - 1) - (1 + \delta)(a_d - \frac{1}{2})] \geq \frac{3}{2}(1 + \delta)$$

If the left hand side is negative then this inequality never holds. Otherwise β_d is chosen at its maximal value such that $4 + \beta_d = \frac{(1+\delta)^2}{3\delta}$ and the inequality boils down to

$$3\delta a_f - (1 + \delta)a_d \geq 3\delta + \frac{9\delta - (1 + \delta)^2}{2(1 + \delta)}$$

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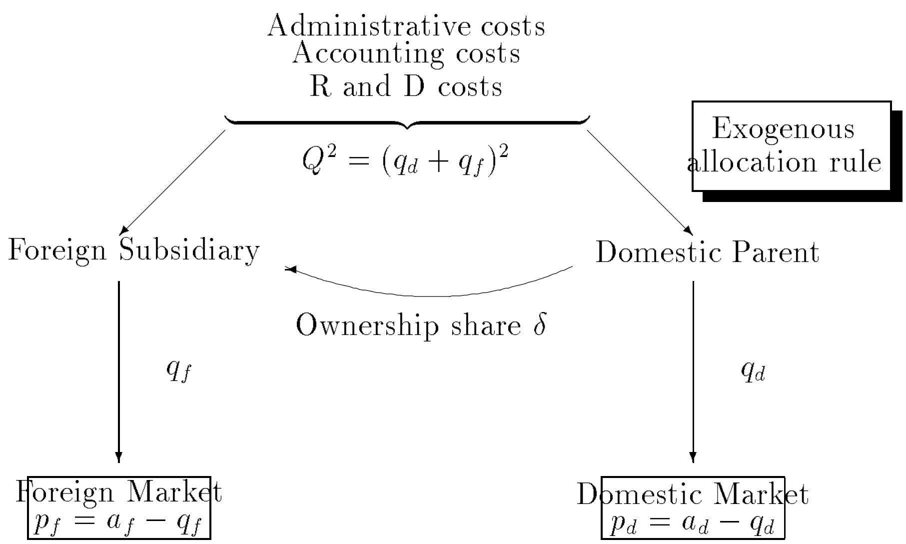

Figure 1: A (simplified) modelisation of the Mne.

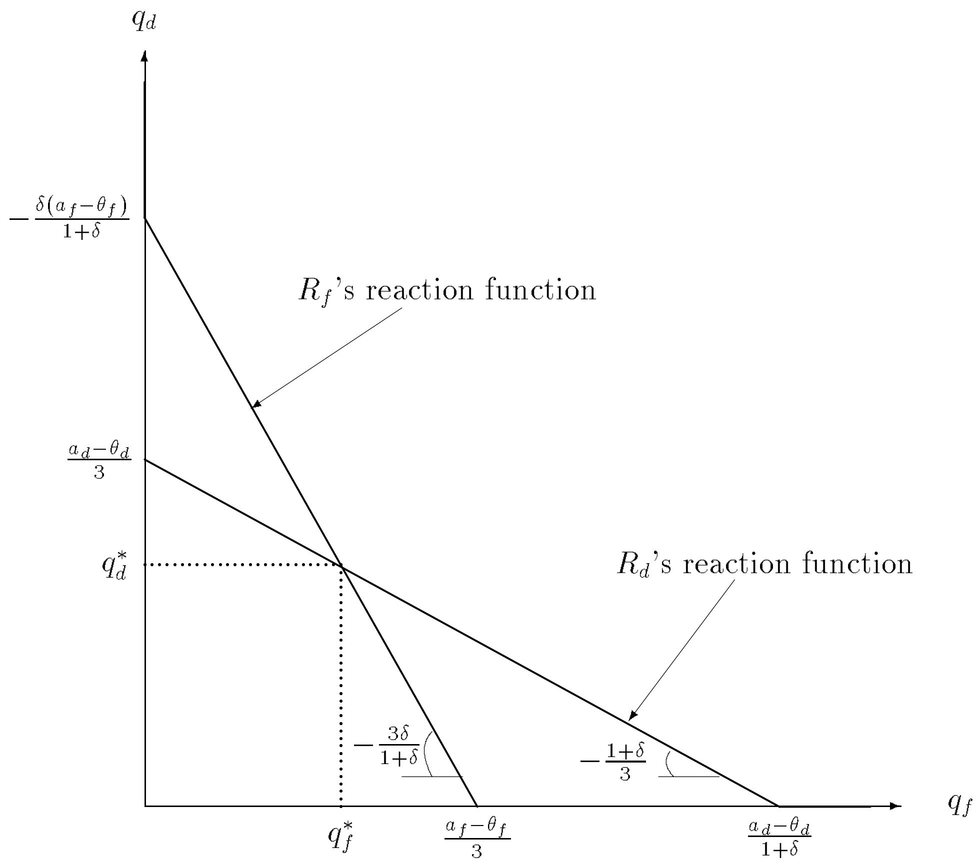

Figure 2: Best-response functions under complete information.

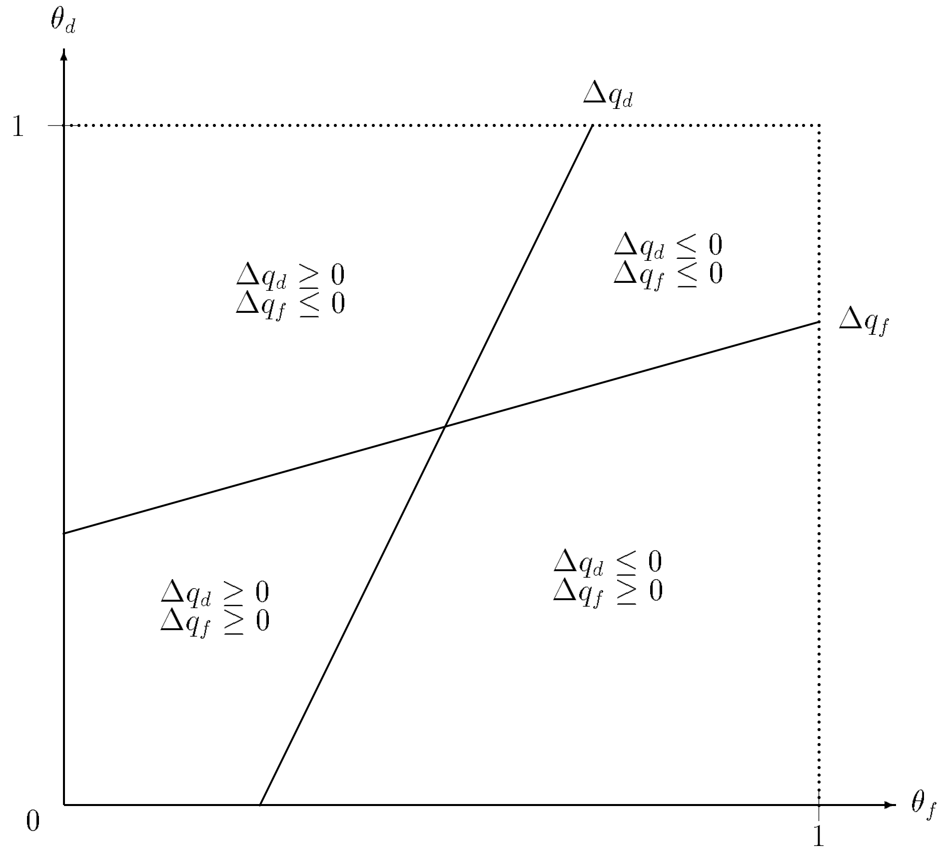

Figure 3: Difference between second- and first-best quantities.

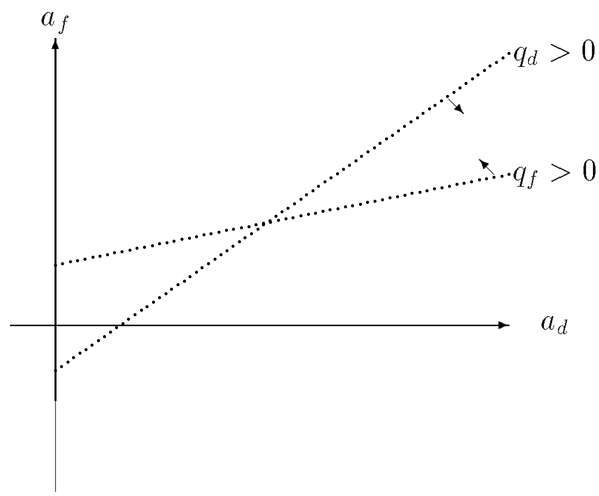

Figure 4: Positivity of equilibrium quantities.

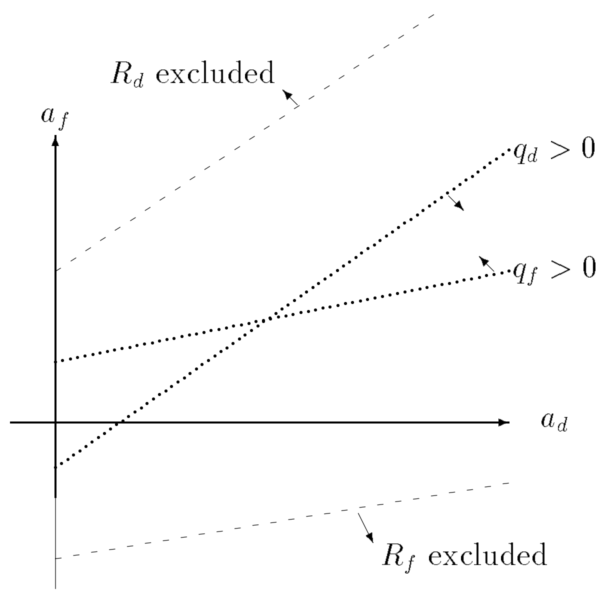

Figure 5: Intrinsic exclusion.

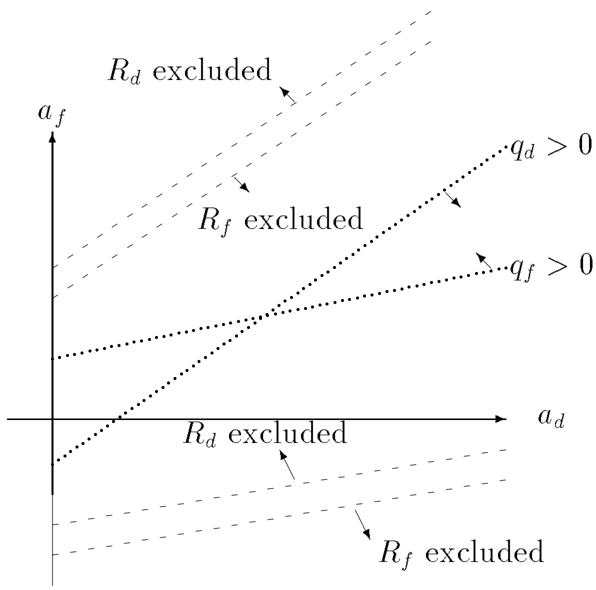

Figure 6: Voluntary exclusion.