Jel.class.no.: D82, H21, L51
Keywords: Common agency, tax competition, mobility, countervailing incentives

Introduction

Lower barriers to entry and liberalisation in world capital markets have increased the actual and potential mobility of multinational enterprises (MNEs). This poses challenges for host countries' tax and regulation policies. For a number of countries, such as, for example, the member countries of the European Union, the policy challenge is two-faceted. First, they are facing strategic tax competition from other similar (e.g. EU member) countries, where the national governments try to attract new corporate investments. Second, the MNEs may have attractive investment and localisation options in entirely different countries (outside the EU-area), e.g., in tax havens or low cost countries. In this paper we analyse tax competition where these two forces are simultaneously present, and study its consequences for an MNE's investment decisions. footnote

The analysis is couched in terms of a common agency model, where two countries (principals) independently design competing tax/regulation policies towards a multinational enterprise (the agent), which divides its real investment portfolio between the two countries. The MNE has an option of redirecting parts of the investments from one country to the other, but it is assumed not to be optimal for the MNE to make all its investments in only one of the two countries. Besides these investment opportunities, the firm has an additional option of investing in another economic area. By retracting to this area, where the tax authorities are assumed to be passive, the firm may avoid taxation by the two first countries and secure itself some 'outside value'. In line with the complex characteristics of most multinational firms, footnote we assume that the firm has better information than the governments about its efficiency in its operations inside as well as outside the two countries. footnote We consider the case where efficiency is is positively correlated across these operations, and assume for simplicity that the correlation is perfect. Technically, the model is thus one of common agency with hidden information footnote and a type-dependent outside value for the agent. The latter feature makes the model new relative to the received literature on common agency, and our equilibrium results are therefore new contributions to this literature.

In the competitive taxation setting, the MNEs' outside investment options impose a mobility (participation) constraint on the active (e.g. EU) tax authorities: the firm's after-tax return on investments in their combined jurisdictions (the EU area) should be equal to or exceed the return after tax and mobility costs on the best alternative outside investment. In addition, the governments face incentive constraints since the firm possesses private information about its efficiency and thereby its profitability. As part of a tax bargaining strategy the firm may have an incentive to misrepresent its earning potential in each individual country. Also, having investment opportunities in several countries, the MNE may try to reduce tax payments in each jurisdiction by an implicit threat of directing a larger fraction of its investment to the neighbouring country or the alternative economic area, or even threaten to migrate out of the present economic area altogether. footnote In this case it is possible that the MNE is faced with countervailing incentives, see Lewis and Sappington (1989), Maggi and Rodríguez-Clare (1995), and Jullien (1996). On the one hand, to reduce tax payments the firm would like to report a low productivity in the EU-countries. To reduce taxes it would also like to indicate that it is highly mobile, i.e., unless taxes in the EU-area is reduced, it may reschedule investments or migrate altogether to another region where costs or taxes are lower. To signal a credible threat of relocation, the firm would like to report a high reservation profit, i.e., it would like to report a high productivity on alternative investments. However, when the firm's productivities inside and outside the EU-area are correlated, it cannot at the same time report a low and a high productivity. In this situation of countervailing incentives the outside option of the firm may actually have the effect of limiting the firm's information rent (although its total rent, including mobility rent, will increase).

This paper complements the regulation theory literature by combining countervailing incentives and common agency. We give some characterization results, and derive explicit equilibria for the case of quadratic return functions and uniform probability distributions. Comparative statics results for these equilibria are presented. It is shown that the presence of countervailing incentives generated by an outside option does change qualitative results in common agency. For instance, while the standard common agency model under our assumptions (including contract substitutes and a continuos type distribution) yields unique differentiable equilibrium schedules for the firm's investments (as functions of its efficiency type), footnote we typically obtain a whole family of such equilibrium schedules in the extended model. In particular, there are asymmetric equilibria even when the taxing countries are in all relevant aspects symmetric. The Pareto-preferred equilibrium is however shown to be symmetric in that case.

Multiprincipal regulatory problems with the presence of countervailing incentives has previously been analysed by Mezzetti (1997), but in a different setting: optimal incentives and organisational design are developed for a case where two principals share a common agent, and where the agent has private information about his *relative* productivity in the tasks he performs for the two principals. With this informational assumption, and by formulation of a specific cost function, Mezzetti obtains a case of countervailing incentives. We focus on private information about the absolute efficiency level, and the presence of countervailing incentives is in our model due to an outside option. These two information structures have quite different implications; whereas Mezzetti obtain equilibria with pooling for a range of intermediate types, we obtain fully separating equilibria, and whereas Mezzetti obtains a unique equilibrium, the equilibrium investment schedules are typically not unique in our model. Another departure from the model of Mezzetti, which has implications for the qualitative results, is that we address a case of substitutes, whereas in Mezzetti's model there is complementarity between the two tasks performed by the agent.

We model a tax bargaining situation between a unique, large MNE and two independent countries, which engage in strategic tax competition. Focus is on private information about productivity, i.e., issues of intra-firm trade and transfer pricing are not considered. footnote The outside region introduced here is assumed to be a passive player. This assumption may have several justifications. First, the outside option may represent many low-cost countries or tax havens which have perfect tax competition among themselves. Second, the outside option may be represented by a low-cost or a low-tax country that plays against many countries in the region where the MNE is presently located, and thus will not be affected by tax changes in one small EU-country. Third, the alternative location region may even play strategically, but is dominated by the EU-countries, e.g., because of lack of skilled labour and adequate infrastructure. footnote

The present paper is an extension of Olsen and Osmundsen (1998), which departs from the common agency models of Martimort (1992) and Stole (1992) by letting the principals assign a positive value to the agent's information rents. footnote This affects qualitative results by inducing equity externalities. In the present paper we further extend the framework developed by Martimort and Stole by including an outside investment option which induces countervailing incentives. Optimal (single-agency) taxation subject to private information about the value of an outside option, has previously been addressed by Favardin and Soubeyran (1995), Osmundsen, Hagen and Schjelderup (1998), and Osmundsen (1999), where the last two articles also address the issue of countervailing incentives. All three analyses presume that foreign governments implement a traditional tax system, while the single home country imposes an incentive mechanism designed to extract more rent from the tax subjects.We extend the model to allow for a response from a foreign country, i.e., to take into account strategic interaction among governments.

In the common agency literature (for substitutes), and the theory of tax competition under symmetric information, footnote it is the case that investments are higher under competing than under cooperating principals, and that the agent benefits from competition between principals. For complementary activities, Bond and Gresik (1996) find that activity levels always are lower with competing than with cooperating principals, and that the firm always is better off under cooperative taxation. footnote We show that with the presence of an outside option, tax competition, relative to tax coordination, may entail lower investments for inefficient types and higher investments for efficient types, and that he firm's profits may be lower or higher when the countries compete than when they cooperate. Whether the firm is better or worse off under tax competition relative to tax coordination, depends among other things on its ownership structure. Moreover, the presence of an outside option makes the investment equilibria inherently non-unique. We also show that a higher outside option for the firm may actually be beneficial for the taxing countries when they compete.

The model

The particular features of the model are as follows. The MNE invests K_1 in country 1 and K_2 in country 2, footnote yielding profits (before joint costs and taxes) $N_1(K_1,\theta)$ and $N_2(K_2,\theta)$, where θ is an efficiency parameter. The MNE also has an option of investing in another economic area. To simplify we assume that if the MNE exercises this option, it moves all its operations to this region. Given a passive government in the outside region, this assumption mainly serves to simplify notation. An alternative setup would be to assume that the MNE in equilibrium actually invests in a third country, in which case the outside option would be to reschedule a larger fraction of its activities to this country. This alternative approach would generate the same qualitative results; see the appendix.

We assume that it is not optimal for the MNE to make all its investments only in country 1 or only in country 2. There are several examples that may motivate this assumption. First, consider a vertically integrated MNE which is located in two EU-countries (e.g., coal mining and natural gas extraction). Extraction levels exceed local demand, and excess output is exported to the neighbouring country, due to high transportation costs. Such a firm cannot credibly threaten to concentrate all its activities in only one of the countries. The outside option of the firm may be to extract natural resources and serve customers in another region. The second case is an MNE (e.g., in the food industry), that is presently located in two EU-countries. footnote The MNE is likely to maintain some activity in both countries due to irreversible investments that have been made in production facilities. Even without the presence of fixed factors, the firm may want to be present in both of the countries in order to be close to the customers and thus closely observe changing consumer patterns. footnote A third explanation for localisation in several countries is that the MNE is a multi-product firm, e.g., a producer of household appliances or semi-conductors, and that the countries differ with respect to the presence of industrial clusters for different types of products. footnote Lower trade costs may open up the possibility to locate in low cost or low tax regions, i.e., outside options may emerge.

Let Π and π denote, respectively, the pre- and post-tax global profits of the firm:

$$\Pi(K_1,K_2,\theta) = N_1(K_1,\theta) + N_2(K_2,\theta) - C(K), \quad \#$$

$$\pi = \Pi - r_1 - r_2, \quad \#$$

where $K = K_1 + K_2$, $C(K)$ denotes joint costs for the two affiliates and r_1 and r_2 are the taxes paid to the two countries. footnote We assume that $C'(K) > 0,\ C''(K) > 0$. The convex costs $C(K)$ imply economic interaction effects among the two affiliates; an increase in the investments in one of the countries implies a higher marginal joint cost, which again affects the investments of the other country. These joint costs may have different interpretations. First, K may represent scarce human capital, e.g., management resources or technical personnel, where we assume that the MNE faces convex recruitment and training costs. Second, K may represent real investments, where $C(K)$ are management and monitoring costs of the MNE. Economic management and co-ordination often become more demanding as the scale of international operations increase, i.e., $C(K)$ is likely to be convex. Third, instead of interpreting $C(K)$ as joint costs, it may in the case of imperfect competition be perceived as measuring interaction effects in terms of market power. For example, if the two affiliates sell their output on the same market (e.g., in a third country), their activities are substitutes: high investments (and output) in affiliate 1 reduce the price obtained by affiliate 2. Another example of a market interaction effect is a case where K_1 and K_2 are investments in R&D; the marginal payoff on R&D-activities of affiliate 1 is lower the higher is the R&D activity of affiliate 2, e.g., due to a patent race. footnote

The countries compete to attract scarce real investments from the MNE, and the interaction of the principals is through the MNE's joint costs. Note that $\frac{\partial^2\Pi}{\partial K_1 \partial K_2} = -C''(K) < 0,$ e.g., we address a case of contracting substitutes. The affiliates of the MNE are separate and independent entities, which means that they are subsidiaries and thus taxed at source. The firm has private information about θ and net operating profits in the two countries. It is presumed that if the firm is efficient in one country it is also an efficient operator in the other country; for reasons of tractability we assume that the firm has the same efficiency in the two countries. It is common knowledge among the governments of the two countries (the principals) that the efficiency types are distributed according to the differentiable density function $f(\theta) > 0$, with corresponding cumulative distribution function $F(\theta)$ having the support $[\underline{\theta}, \bar{\theta}]$, where $\underline{\theta}$ denotes the least and $\bar{\theta}$ the most efficient type. The probability distribution satisfies the regularity conditions $\frac{d}{d\theta}[F(\theta)/f(\theta)] \geqslant 0$ and $\frac{d}{d\theta}[(1 - F(\theta))/f(\theta)] \leqslant 0$. Efficient types have higher net operating profits than less efficient types, both on average and at the margin: $\frac{\partial N_j}{\partial \theta}(K_j, \theta) > 0$ and $\frac{\partial^2 N_j}{\partial \theta \partial K_j}(K_j, \theta) > 0,$ $j = 1, 2;$ where the latter inequality is a single crossing condition.

The MNE and the governments are risk neutral. For all efficiency types the affiliate's net operating profits in each country are sufficiently high so that both governments always want to induce the domestic affiliate to make some investments in their home country. Domestic consumer surpluses in the two countries are unaffected by changes in the MNE's production level, since the firm is assumed to be a price taker (or its market is outside the two countries). The governments have utilitarian objective functions: the social domestic welfare generated by an MNE of efficiency type θ is given by a weighted sum of the domestic taxes paid by the firm and the firm's global profits:

$$W_j = (1 + \lambda_j) r_j + \alpha_j \pi, \;\; j = 1, 2,$$

where λ_j is the general equilibrium shadow cost of public funds in country j, and α_j is the owner share of country j in the MNE. The shadow costs of public funds are taken as exogenously given in our partial analysis. We have that $\lambda_j > 0, \;\; j = 1, 2,$ since marginal public expenditure is financed by distortive taxes. By inserting for Eq.(ref: P), the social welfare function for country 1 can be restated as

$$W_1 = (1 + \lambda_1)(\Pi(K_1, K_2, \theta) - r_2) - (1 + \lambda_1 - \alpha_1)\pi. \qquad \#$$

The MNE has an additional localisation alternative: it has an option of moving all its activity outside the EU area, e.g., to a low cost country or to a tax haven. This investment option would produce an after tax profit of $n(\theta)$, i.e., the firm has private information about the alternative return on its scarce resources.

To analyse the MNE's incentives for strategic reporting of its efficiency type, let (with a slight abuse of notation) $\pi(\theta)$ denote the firm's equilibrium post tax profits, so we have the participation constraint $\pi(\theta) \geq n(\theta), \; \forall \theta \in [\underline{\theta}, \bar{\theta}]$. Assuming that firms that have high returns in the EU area also have high returns on outside options, we have $n'(\theta) > 0$. Now, if these outside returns are for every type no larger than the equilibrium profits for the EU area found in the case where $n(\theta)$ is constant, this equilibrium will prevail also when the firm has the option to move out of the area. So we consider here the case where the participation constraint is binding for some type(s) other than the least productive one, i.e., for some type $\theta \neq \underline{\theta}$. In these cases there are typically countervailing incentives, where low-productivity types are tempted to claim to have high productivity in order to secure themselves high rents. To illustrate these effects, and yet have a fairly simple model, we shall confine ourselves to cases where the participation constraint is binding only for the least productive and the most productive type, i.e., only for $\theta = \underline{\theta}$ and $\theta = \bar{\theta}$. This will typically occur if the outside returns function $n(\theta)$ is 'sufficiently convex', in a sense to be made precise below.

Cooperating principals

When the agent possesses private information and the principals cooperate, the solution procedure is analogous to the familiar single principal case. The principals seek to maximise the cooperative welfare given by $W = W_1 + W_2$ (we assume $\lambda_1 = \lambda_2$) subject to incentive and participation constraints. The standard procedure is to analyse this in terms of direct revelation mechanisms. footnote The firm is then asked to make a report $\hat{\theta}$, in response to which it is asked to invest $K_1(\hat{\theta})$ and $K_2(\hat{\theta})$ and to pay the taxes $r_1(\hat{\theta})$ and $r_2(\hat{\theta})$. This yields profits $\pi(\hat{\theta},\theta) = \Pi\left(K_1(\hat{\theta}),K_2(\hat{\theta}),\theta\right) - r_1(\hat{\theta}) - r_2(\hat{\theta})$. Incentive compatibility requires that the firm's optimal choice of $\hat{\theta}$ is θ (i.e., $\pi(\hat{\theta},\theta) \leq \pi(\theta,\theta)$); hence it requires that footnote

$$\pi'(\theta) = \frac{\partial\Pi}{\partial\theta}(K_1(\theta),K_2(\theta),\theta) = \frac{\partial N_1(K_1(\theta),\theta)}{\partial\theta} + \frac{\partial N_2(K_2(\theta),\theta)}{\partial\theta}, \qquad \#$$

where $\pi(\theta) \equiv \pi(\theta,\theta)$, and the second equality follows from the definition of Π. It is also necessary that $\sum_j \frac{\partial^2\Pi}{\partial K_j\partial\theta}(K_1(\theta),K_2(\theta),\theta)K_j'(\theta) \geq 0$. The first-order condition (ref: IC) together with $K_j'(\theta) \geqslant 0, j = 1,2$ are sufficient for incentive compatibility.

Each principal maximizes expected welfare EW subject to the incentive compatibility (IC) and participation (IR) constraints. footnote Here we confine ourselves to the case of a "strongly convex" outside option function $n(\theta)$. The IR constraints will then not bind for any interior type.

Proposition *Suppose there is a $\check{\theta} \in [\underline{\theta},\bar{\theta}]$ such that $K_1(\theta),K_2(\theta)$ given by*

$$(K_1(\theta),K_2(\theta)) = arg\max_{K_1,K_2}\left[\Pi(K_1,K_2,\theta) - (1 - \frac{\alpha_1+\alpha_2}{1+\lambda})\frac{\partial\Pi}{\partial\theta}(K_1,K_2,\theta)\frac{F(\check{\theta}) - F(\theta)}{f(\theta)}\right]$$

are increasing ($K_j'(\theta) \geq 0$) or, more generally, incentive compatible. Suppose further that the associated rent $\pi(\theta)$ given by (ref: IC), i.e., $\pi(\theta') = \int_{\underline{\theta}}^{\theta'} \frac{\partial\Pi}{\partial\theta}(K_1(\theta),K_2(\theta),\theta)d\theta + \pi(\underline{\theta})$, satisfies $\pi(\theta) \geq n(\theta)$ and
(a) $\pi(\underline{\theta}) = n(\underline{\theta})$ if $\check{\theta} = \bar{\theta}$.
(b) $\pi(\underline{\theta}) = n(\underline{\theta})$ and $\pi(\bar{\theta}) = n(\bar{\theta})$ if $\underline{\theta} < \check{\theta} < \bar{\theta}$.
(c) $\pi(\bar{\theta}) = n(\bar{\theta})$ if $\check{\theta} = \underline{\theta}$.
Then $(K_1(\theta),K_2(\theta))$ together with the associated rent $\pi(\theta)$ is the optimal solution. Moreover, if $K_j'(\theta) > 0, j = 1,2,$ this solution entails tax payments such that total tax revenue $r_1(\theta) + r_2(\theta)$ is increasing for $\theta < \check{\theta}$ and decreasing for $\theta > \check{\theta}$.

For completeness a *proof* is included in the appendix. To interpret the optimal solution, note that the first order conditions for optimal investments take the form

$$\frac{\partial\Pi}{\partial K_j} - \frac{1+\lambda-\alpha_1-\alpha_2}{1+\lambda}\frac{\partial^2\Pi}{\partial\theta\partial K_j}\frac{F(\check{\theta}) - F(\theta)}{f(\theta)} = 0, j = 1,2. \qquad \#$$

The first term captures the marginal surplus in production, the second term the marginal welfare effect associated with the firm's rents. When $\check{\theta} = \bar{\theta}$ - the conventional case - the latter effect is negative, i.e., it amounts to a welfare cost for all types except the most efficient one. Optimal investments are then (at least for symmetric returns) lower than their first-best levels. If $\check{\theta} \in (\underline{\theta},\bar{\theta})$, the second term above is negative for $\theta > \check{\theta}$, so the welfare effect associated with the firm's rents is positive for such a type. For these types the incentive constraints are binding upwards; the firm is tempted to mimic a more efficient type in order to make it appear that it has a higher outside option. By inducing such a firm to invest more, and thereby increase its ”internal” profits, $\pi(\theta)$, the incentive constraints for firms with lower efficiency (types in the range $(\check{\theta},\theta)$) are relaxed. This leads (for symmetric returns) to overinvestments relative to the first-best solution for these types.

While tax revenues in the conventional case (a) are increasing with the firm’s efficiency, they are in case (b), where an outside option exerts an influence, maximal for some intermediate efficiency type. From this we can also conclude that total welfare in some such cases will be non-monotonic in efficiency, and thus also maximal for an intermediate type. footnote

Non-cooperative equilibrium

Consider now the case where the governments of the two countries compete (to attract the firm’s investments) rather than cooperate. In this case the MNE relates to each government separately. The governments cannot credibly share information and they act non-cooperatively. Analogous to Stole (1992) we assume that the firm makes separate reports to the two governments about its efficiency, $\hat{\theta}_1$ and $\hat{\theta}_2$, and that each principal observes only the report meant for him. Let r_j denote the taxes that the firm pays to government j, and let $\left\{r_j(\hat{\theta}_j),K_j(\hat{\theta}_j),\hat{\theta}_j \in [\underline{\theta},\bar{\theta}]\right\},j = 1,2,$ be direct mechanisms that induce truthful revelation of the firm’s efficiency parameter. footnote The MNE’s profits as a function of reports and type are now given by

$$\pi(\hat{\theta}_1,\hat{\theta}_2,\theta) \equiv \Pi(K_1(\hat{\theta}_1),K_2(\hat{\theta}_2),\theta) - r_1(\hat{\theta}_1) - r_2(\hat{\theta}_2).$$

The incentive compatibility (truthfulness) constraints are then $\pi(\hat{\theta}_1,\hat{\theta}_2,\theta) \leq \pi(\theta,\theta,\theta)$ for all feasible $\hat{\theta}_1,\hat{\theta}_2,\theta$. Following Stole (1992) we call these the common incentive compatibility constraints (CIC). As in the cooperative case, the constraints imply (ref: IC), where now $\pi(\theta) = \pi(\theta,\theta,\theta)$. We say that a pair $K_1(\theta_1),K_2(\theta_2)$ of investment profiles are commonly implementable if there are tax schedules $r_j(\theta_j)$, one for each principal, such that the pair of contracts satisfy (CIC). A pair of contracts is commonly feasible if in addition the participation constraints $\pi(\theta) \geq n(\theta)$ are satisfied.

Stole derives necessary (Thm. 4, Cor. 1) and sufficient (Thm. 5) conditions for common implementability. The necessary conditions include the second-order conditions for local concavity of $\pi(\hat{\theta}_1,\hat{\theta}_2,\theta)$ at the point $(\hat{\theta}_1,\hat{\theta}_2) = (\theta,\theta)$, which amount to:

$$\begin{gathered}\tfrac{\partial^2\Pi}{\partial K_1\partial K_2}K_1'K_2' + \tfrac{\partial^2\Pi}{\partial\theta\partial K_i}K_i' \geq 0, \qquad i = 1,2, \\ K_1'K_2'\left(\tfrac{\partial^2\Pi}{\partial\theta\partial K_1}\tfrac{\partial^2\Pi}{\partial\theta\partial K_2} + \tfrac{\partial^2\Pi}{\partial K_1\partial K_2}\left[\tfrac{\partial^2\Pi}{\partial\theta\partial K_1}K_1' + \tfrac{\partial^2\Pi}{\partial\theta\partial K_2}K_2'\right]\right) \geq 0.\end{gathered} \qquad \#$$

These conditions are (in conjunction with (ref: IC)) also sufficient when the cross-partial derivatives of the agent’s profit function are constant, the agent’s decision variables are substitutes, and the investment schedules to be implemented are nondecreasing. footnote

By a procedure analogous to that leading to Proposition 1 for the cooperative case, we can show the following result

Lemma *Suppose $(K_1(\theta),K_2(\theta))$ is a pair of non-decreasing schedules that is commonly implementable, with associated tax schedules $(r_1(\theta),r_2(\theta))$. Let*

$$\hat{\theta}_i(k_j,\theta) = argmax_{\hat{\theta}_i'}\left[\Pi\left(k_j,K_i(\hat{\theta}_i'),\theta\right) - r_i(\hat{\theta}_i')\right], \qquad k_j \geq 0,$$

and suppose that there are $\check{\theta}_1,\check{\theta}_2 \in (\underline{\theta},\bar{\theta})$ such that $K_j(\theta) = arg\ max_{k_j}\left[G_j(k_j,\theta,\check{\theta}_j)\right]$, where

$$\begin{aligned}G_j(k_j,\theta;\check{\theta}_j) &= \Pi(k_j,K_i(\hat{\theta}_i(k_j,\theta)),\theta) - \Pi(K_j(\theta),K_i(\hat{\theta}_i(k_j,\theta)),\theta) \\ &\quad - \frac{1+\lambda-\alpha_j}{1+\lambda}\frac{\partial\Pi}{\partial\theta}(k_j,K_i(\hat{\theta}_i(k_j,\theta)),\theta)\frac{F(\check{\theta}_j)-F(\theta)}{f(\theta)}.\end{aligned} \qquad \#$$

Suppose also that the associated rents $\pi(\theta)$ for the agent, given by

$$\pi(\theta') = \int_{\underline{\theta}}^{\theta'} \frac{\partial \Pi}{\partial \theta}(K_1(\theta), K_2(\theta), \theta) d\theta + \pi(\underline{\theta}), \qquad \#$$

satisfy $\pi(\theta) \geq n(\theta)$ with equality for $\theta = \underline{\theta}$ and for $\theta = \bar{\theta}$. Then (K_1, K_2) is a common-agency equilibrium.

A proof is given in the appendix. Note that $\hat{\theta}_i(k_j, \theta)$ is the firm's optimal report to the principal in country i, given that it invests k_j in country j, and has efficiency type θ.

The first order condition for the maximum of of $G_j()$ to be attained at $k_j = K_j(\theta)$ is

$$\frac{\partial \Pi}{\partial K_j} - \frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[\frac{\partial^2 \Pi}{\partial \theta \partial K_j} + \frac{\partial^2 \Pi}{\partial \theta \partial K_i} \frac{\partial}{\partial K_j} K_i(\hat{\theta}_i(K_j, \theta)), \theta) \right] \frac{F(\check{\theta}_j) - F(\theta)}{f(\theta)} = 0,$$

where all terms are evaluated at $K_j = K_j(\theta)$, $K_i = K_i(\theta)$ (and therefore $\hat{\theta}_i(K_j, \theta) = \theta$ by CIC). The first term in the formula represents the marginal surplus, the second (main) term the marginal effects on rents. This term has itself two components; the first is the conventional (direct) one (first-order rent effect), just like in the cooperative case; the second is a strategic effect (second-order rent effect), working through the change in foreign investments ($\frac{\partial K_i}{\partial K_j}$) induced by the change in domestic investments. This is a fiscal externality which is due to the ability of government j - via a strategic tax policy - to affect the report made by the MNE to government i, and thereby affect K_i. As shown in the appendix, the latter investment effect is (in equilibrium) given by

$$\frac{\partial K_i}{\partial K_j} = K_i'(\theta) \frac{\partial \hat{\theta}_i}{\partial K_j}(K_j(\theta), \theta) = \frac{\frac{\partial^2 \Pi}{\partial K_i \partial K_j} K_i'(\theta)}{\frac{\partial^2 \Pi}{\partial \theta \partial K_i} + \frac{\partial^2 \Pi}{\partial K_i \partial K_j} K_j'(\theta)}, \qquad \#$$

where all terms are evaluated at $K_j = K_j(\theta)$, $K_i = K_i(\theta)$. If investments are substitutes, increasing in both countries, and commonly implementable, the strategic effect will be negative. The first-order condition for equilibrium investments $K_j(\theta)$ can now be written

$$\frac{\partial \Pi}{\partial K_j} = \frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[\frac{\partial^2 \Pi}{\partial \theta \partial K_j} + \frac{\partial^2 \Pi}{\partial \theta \partial K_i} \frac{\frac{\partial^2 \Pi}{\partial K_i \partial K_j} K_i'(\theta)}{\frac{\partial^2 \Pi}{\partial \theta \partial K_i} + \frac{\partial^2 \Pi}{\partial K_i \partial K_j} K_j'(\theta)} \right] \frac{F(\check{\theta}_j) - F(\theta)}{f(\theta)}. \qquad \#$$

A symmetric condition holds for investments in country i. Except for the parameters $(\check{\theta}_1, \check{\theta}_2)$, the conditions (ref: DEQ) are analogous to the equilibrium conditions derived by Stole (1992) and others for the conventional case where the outside value is type independent. The conventional case corresponds to $\check{\theta}_1 = \check{\theta}_2 = \bar{\theta}$. Conditional on the parameters $(\check{\theta}_1, \check{\theta}_2)$, the two conditions define a pair of differential equations for the equilibrium investment schedules. If these equations have solutions, one can check whether, for some combination $(\check{\theta}_1, \check{\theta}_2)$, the other conditions in the Lemma are satisfied. If they are, the solution obtained in this way is an equilibrium. Thus we have the following result.

Proposition *Suppose $(K_1(\theta), K_2(\theta))$ is a pair of non-decreasing schedules that is commonly implementable and satisfies the differential equations (ref: DEQ) for some combination $(\check{\theta}_1, \check{\theta}_2)$, with $\check{\theta}_j \in (\underline{\theta}, \bar{\theta})$. Suppose also that $G_j(k_j, \theta, \check{\theta}_j)$ given in (ref: GJ) is for every θ qusiconcave in k_j. Suppose finally that the associated rents $\pi(\theta)$ for the agent (the MNE), given by (ref: RNT) satisfy $\pi(\theta) \geq n(\theta)$ with equality for $\theta = \underline{\theta}$ and for $\theta = \bar{\theta}$. Then $(K_1(\theta), K_2(\theta))$ is a common-agency equilibrium.*

Thus far we have only considered equilibria in revelation mechanisms. A relevant question is whether the equilibrium outcome in this game also arises as the equilibrium outcome of a taxation game where the principals offer tax functions $R_j(K_j)$, i.e. where the tax payment to principal j only depends on investments K_j in country j. If so, the tax schedules must satisfy the first-order conditions $\frac{\partial \Pi}{\partial K_j}(K_j, K_i, \theta) = R_j'(K_j)$ for $K_j = K_j(\theta)$, $K_i = K_i(\theta)$, for every type θ.

Assuming that the investment profiles are invertible (e.g. strictly increasing in θ), we define $\theta_j(K)$ to be the inverse of $K_j(\theta)$. The first-order condition for K_j then takes the form

$$\frac{\partial\Pi}{\partial K_j}(K_j, K_i(\theta_j(K_j)), \theta_j(K_j)) \;\; = R_j'(K_j). \qquad \#$$

This relation will determine the marginal tax rate for investments in the range, say $[\underline{K}_j, \bar{K}_j]$ of $K_j(\theta)$, i.e. for investments that arise as an equilibrium outcome for some type θ. Extending the tax functions outside this range, two conditions must be met: (i) the extended tax functions must implement $K_1(\theta)$,$K_2(\theta)$, and (ii) they must be mutually best responses for the principals. In the next section, where we consider the case of a quadratic profit function $\Pi(K_1, K_2, \theta)$ and a uniform distribution, we show that this can be done by extending the tax functions linearly outside the equilibrium range.

In the quadratic-uniform case we obtain equilibrium investment schedules $K_j(\theta)$ that are linear in the efficiency parameter θ. Figure 1 provides an illustration for the case where the two countries are completely symmetric ($\Pi(K_1, K_{2,}\theta)$ is symmetric and owner shares are equal; $\alpha_1 = \alpha_2$). The first-best (full information) investment schedules are then symmetric across the countries, and so are the second-best (asymmetric information) schedules obtained in the cooperative tax regime. These are depicted as, respectively, the heavy line (first-best) and the broken line (second-best) in the figure. The thin line represents the investment schedule for a symmetric equilibrium in the non-cooperative tax regime. footnote Its qualitative properties are similar to those of the solution under tax cooperation; there is underinvestment relative to the first-best for low-efficiency types ($\theta < \check{\theta}_j$) and overinvestment for high-efficiency types ($\theta > \check{\theta}_j$). footnote As discussed below, the relative positions of the investment schedules for the two tax regimes will vary, depending on the parameters of the model. The figure depicts a case where competition in some sense exacerbates investment distortions: investments under competition are for low-efficiency types even lower and for high-efficiency types even higher than investments under cooperation.

FIGURE 1

We will now point out some results suggested by the analysis above. For the general functional forms used so far, we will only provide suggestive and intuitive explanations. In the following section we prove these results for the case of a quadratic profit function $\Pi(K_1, K_2, \theta)$ and a uniform distribution $F(\theta)$.

(*i*) *non-uniqueness of* (*differentiable*) *equilibrium investment schedules*. An equilibrium as that in Proposition 3 appears to be generically non-unique. The reason is that the system of equations that determine an equilibrium has 'one degree of freedom'. The differential equations (ref: DEQ) will normally have a family of solutions, indexed by the parameters $(\check{\theta}_1, \check{\theta}_2)$. Since one IR constraint, such as $\pi(\underline{\theta}) = n(\underline{\theta})$, is used determine the rent for the least efficient type, there remains only one constraint, namely $\pi(\bar{\theta}) = n(\bar{\theta})$, to determine the two parameters $(\check{\theta}_1, \check{\theta}_2)$. Contrary to the cooperative case, where there is only one parameter to be determined, the non-cooperative case leaves one degree of freedom for the equilibrium solution. There are of course other (assumed non-binding) participation and incentive constraints, but as we show in the next section, there is in the uniform-quadratic case a family of (linear) investment schedules that satisfy all equilibrium conditions. We thus verify non-uniqueness for this class of return and distribution functions. Non-uniqueness holds true also when the countries are symmetrical in all respects, hence we verify that there are equilibria with non-symmetric investments when the countries are symmetric. The Pareto-preferred equilibrium, however, is shown to be unique and symmetric for that case.

(*ii*) *uniqueness of equilibrium rents* $\pi(\theta)$. The family of equilibria identified for the uniform-quadratic case turns out to have the property that, although investment levels are different across these equilibria, the firm's rents are the same in all of them. The reason is essentially that the firm's marginal equilibrium rents, given by $\pi'(\theta) = \frac{\partial\Pi}{\partial\theta}(K_1(\theta), K_2(\theta), \theta)$ (as required by incentive compatibility), stay constant even if the investment levels $K_1(\theta), K_2(\theta)$

vary across equilibria. It seems that this will hold true also for a larger class of return and distribution functions.

(*iii*) *tax competition may, relative to tax coordination, decrease or increase the firm's rents*. To see that tax competition may decrease the firm's rents, consider the case where there are no outside owners, i.e., $\alpha_1 + \alpha_2 = 1$, the countries are symmetric in all respects, and λ is close to zero. Under tax coordination the motive for rent extraction is then very weak, since all rents accrue to domestic owners, and the costs of public funds are small. Provided the outside value for the firm is not too high, the optimal investment levels are then close to the first-best levels $(K_{1F}(\theta), K_{2F}(\theta))$, and marginal rents are (with close approximation) given by $\pi'(\theta) = \frac{\partial \Pi}{\partial \theta}(K_{1F}(\theta), K_{2F}(\theta), \theta)$.

Under tax competition there is a much stronger incentive for each country to extract the firm's rents, since half of those rents accrue to owners living in the other country. In the symmetric equilibrium there is then significant underinvestments (relative to the first best) for firms with low efficiency ($\theta < \check{\theta}_j$). If the participation constraint is binding for the most efficient type, there is overinvestments for the more efficient types ($\theta > \check{\theta}_j$). Since lower (respectively higher) investments mean lower (respectively higher) marginal – and therefore also absolute – rents, we see that the rents for firms with low efficiency will be lower under tax competition relative to their rents under tax coordination. The relatively higher investments for high-efficiency types will to some extent work in the opposite direction on the firm's rents, but at least for the functional forms we analyze in detail in the section below, it is the case that rents are for all types in $(\underline{\theta}, \bar{\theta})$ under these conditions lower under tax competition than under tax coordination.

Under other conditions, notably when the outside owner share is large ($\alpha_1 + \alpha_2 \approx 0$) and the cost of public funds is not too small, we find the opposite result, namely that the rents for all types in $(\underline{\theta}, \bar{\theta})$ are higher under tax competition than they are under tax coordination. The intuition for this result is essentially the following. Given that no rents accrue to domestic owners in this case, the principals' motives for rent extraction will be 'equally strong' under the two regimes. The motive for rent extraction leads to investments that are downwards distorted for low-efficiency types and, if the participation constraint is binding at the top, upwards distorted for high-efficiency types. In the competitive regime there is, however, a strategic effect that modifies the investment distortions. Investments will therefore tend to be less distorted downwards for low-efficiency types and less distorted upwards for high-efficiency types in the competitive regime. This is the opposite of what we had above, and we then also get a converse result for the firm's rents: they will in this case be higher in the competitive regime than in the cooperative regime.

(*iv*) *for symmetric countries and symmetric equilibria tax competition entails, relative to tax coordination, lower investments for inefficient types and higher investments for efficient types when λ and the outside owner share are both small. Converse results obtain when the outside owner share is sufficiently large*. The intuition for these results was essentially given in the three previous paragraphs.

(*v*) *A higher outside value is beneficial for the firm. The two taxing countries are negatively affected* (*or possibly not affected*) *by such a higher value if they cooperate, but they may be positively affected if they compete*. The first two assertions are rather obvious. Under tax cooperation the higher outside value will if anything induce a stricter set of participation constraints, and therefore if anything a lower value for the optimization program. To understand the last assertion, consider the case where the countries are symmetric, and where the outside owner share as well as the cost of public funds are zero. Suppose also that the outside value is such that the IR constraint is 'just binding' at the top (so that $\check{\theta}_j = \bar{\theta}$ in the symmetric equilibrium), and otherwise binding only for the least efficient type. Equilibrium investments are then distorted downwards for (almost) all types ($\frac{\partial \Pi}{\partial K_j} > 0$, see (ref: DEQ)). Note that the associated total expected welfare (corresponding to a type θ) now consists only of the production surplus (the firm's pre-tax profits): $W_1 + W_2 = \Pi(K_1(\theta), K_2(\theta), \theta)$. This is so because the total joint cost of leaving rents to the firm, i.e., $(1 + \lambda - \alpha_1 - \alpha_1)\pi$, is by assumption zero. Each individual country considers those fifty percent of the rents that accrue to owners in the other country as a loss, but those rents are of course not a loss for the two countries viewed together.

Now consider a small increase of the outside value, and suppose the IR constraints continue to be binding only for the least efficient and the most efficient types. In order to accommodate higher rents for the firm, investments must increase, at least for some types. For some functional forms, including those considered in Section 5 below, investments will increase for all types in such a case. Since the aggregate welfare effect of increased rents is zero, while the effect of increased investments on the aggregate production surplus is positive (we had $\frac{\partial \Pi}{\partial K_j} > 0$ initially), it follows that the total welfare effect associated with the higher outside value will be positive. The two countries will thus in total benefit from the higher outside value offered to the firm in this case.

Quadratic profit function and uniform $\theta-$distribution.

By assuming specific functions, explicit solutions may be derived. We solve for a case of quadratic profit functions and a uniform distribution. footnote For $\Pi = N_1 + N_2 - C$, let

$C(K) = \frac{1}{2}a(K_1 + K_2)^2$, with $a > 0$;

$N_j(K_j, \theta) = g + m_j(K_j + h)\theta + kK_j - \frac{1}{2}q_jK_j^2,$ with $m_j, k, q_j > 0$;

and $F(\theta) = \theta$ for $\theta \in [0, 1]$. With this parametrization the second-order partials are $\Pi_{12} = -a$, $\Pi_{jj} = -(q_j + a)$, $\Pi_{j\theta} = m_j$.

The full information *first-best* solution is given by $\frac{\partial \Pi}{\partial K_i} = 0$, i.e., $m_j\theta + k - (q_j + a)K_j - aK_i = 0$. This yields linear investment schedules $K_{jF}(\theta) = K'_{jF} \bullet \theta + L_{jF}$, with

$$K'_{jF} = \frac{m_j(q_i + a) - m_i a}{(q_1 + a)(q_2 + a) - a^2}, \qquad L_{jF} = \frac{q_i k}{(q_1 + a)(q_2 + a) - a^2}. \qquad \#$$

We assume that both slopes are positive ($K'_{jF} > 0$).

Second best; cooperating principals

The first-order conditions (ref: CO) for the cooperative case take the form $m_j\theta + k - (q_j + a)K_j - aK_i = \frac{1+\lambda-\alpha_1-\alpha_2}{1+\lambda}m_j(\check{\theta} - \theta)$. This also yields linear solutions $K_{jC}(\theta) = K'_{jC} \bullet \theta + L_{jC}$, and we find

$K'_{jC} = (1 + \gamma_C)K'_{jF}, \qquad L_{jC} = L_{jF} - \gamma_C\check{\theta}K'_{jF},, \qquad \gamma_C = \frac{1+\lambda-\alpha_1-\alpha_2}{1+\lambda}.$

Note that the first-best and second-best solutions coincide for $\theta = \check{\theta}$. In order for the schedules $K_{jC}(\theta)$ to be the true solution, they should satisfy all conditions in Proposition 1. The associated rents are given by $\pi(\theta) = \int_{\underline{\theta}}^{\theta} \frac{\partial \Pi}{\partial \theta} d\theta' + \pi(\underline{\theta})$, where $\frac{\partial \Pi}{\partial \theta} = \Sigma_j m_j(K_{jC}(\theta) + h)$. Since $K_{jC}(\theta)$ is linear, we thus have (for $\bar{\theta} = 1$ and $\underline{\theta} = 0$) $\pi(\bar{\theta}) - \pi(\underline{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \frac{\partial \Pi}{\partial \theta} d\theta = \sum_{j=1}^{2} m_j(L_{jC} + \frac{1}{2}K'_{jC} + h)$.Substituting for L_{jC} and K'_{jC} we may then write

$$\pi(\bar{\theta}) - \pi(\underline{\theta}) = \sum_{j=1}^{2} m_j(L_{jF} - \gamma_C\check{\theta}K'_{jF}. + \frac{1}{2}(1 + \gamma_C)K'_{jF} + h) \equiv U(\check{\theta}), \qquad \#$$

where $U(\check{\theta})$ is defined by the identity. Note that this function, which captures the rent difference between the most efficient and the least efficient type, is decreasing in $\check{\theta}$, and so in particular $U(\bar{\theta}) < U(\underline{\theta})$.

For the outside option we normalize the rent for the least efficient type to $n(\underline{\theta}) = 0$. There are three cases, corresponding to cases (a,b,c) i Proposition 1. Which case applies, depends on the relative magnitudes of the outside profit $n(\bar{\theta})$ and the inside profits $U(\bar{\theta})$ and $U(\underline{\theta})$. As a consequence of Proposition 1 we may formulate the following result.

Corollary *Let K'_{jF}, L_{jF} be given by (ref: KF), and $U(\check{\theta}')$ be defined by (ref: UD), for $\check{\theta}' \in [\underline{\theta},\bar{\theta}]$. For $n(\underline{\theta}) = 0$, let $\check{\theta}$ be defined by (a) $\check{\theta} = \bar{\theta} = 1$ if $n(\bar{\theta}) < U(\bar{\theta})$, (b) $U(\check{\theta}) = n(\bar{\theta})$ if $U(\bar{\theta}) < n(\bar{\theta}) < U(\underline{\theta})$, (c) $\check{\theta} = \underline{\theta} = 0$ if $n(\bar{\theta}) > U(\underline{\theta})$.*
Let $K_{jC}(\theta) = L_{jC} + K'_{jC} \bullet \theta = L_{jF} - \gamma_C\check{\theta}K'_{jF} + (1+\gamma_C)K'_{jF} \bullet \theta$, and let $\pi(\theta)$ be given by $\pi'(\theta) = \sum_{j=1}^{2} m_j K_{jC}(\theta)$, with $\pi(\underline{\theta}) = n(\underline{\theta}) = 0$ in cases (a,b) and $\pi(\bar{\theta}) = n(\bar{\theta})$ in cases (b,c). Then, provided $n(\theta) < \pi(\theta)$, $\theta \in (\underline{\theta},\bar{\theta})$, the investment schedules $K_{jC}(\theta)$, $j = 1,2$, constitute the cooperative solution.

Remark. Case (a) is the conventional one where the outside option is not much more attractive for high-efficiency types than for low-efficiency types. The IR constraint is then binding only for the least efficient type. In case (b), the IR constraints are binding for both the least efficient and the most efficient type, and $\check{\theta}$ is determined by $U(\check{\theta}) = n(\bar{\theta})$, i.e., by the condition that $\pi(\bar{\theta}) = n(\bar{\theta})$; see (ref: UD) and note that $\pi(\underline{\theta}) = n(\underline{\theta}) = 0$. In case (c) the outside option is so attractive for the most efficient type that the IR constraints are binding only for this type. In all cases it is presumed that the IR constraints for intermediate types are not binding. This can be checked by computing $\pi(\theta)$ and check $n(\theta) < \pi(\theta)$ ex post. A sufficient (but not necessary) condition for this to be the case is that $n(\theta)$ is 'more convex' than $\pi(\theta)$, i.e. that $n''(\theta) > \sum_{j=1}^{2} m_j K'_{jC}$.

Competing countries

The second-order conditions (ref: CIC) for common implementability take the form $m_i K'_i \geq aK'_1K'_2$, $i = 1,2$ and $K'_1K'_2(1 - [\frac{a}{m_2}K'_1 + \frac{a}{m_1}K'_2]) \geq 0$. The following conditions are therefore sufficient (and necessary, given $K'_j > 0$)

$$0 \leq \frac{a}{m_i}K'_j \leq 1 \; j = 1,2 \qquad \text{and} \qquad \frac{a}{m_2}K'_1 + \frac{a}{m_1}K'_2 \leq 1. \qquad \#$$

The equilibrium equations (ref: DEQ) take the form:

$$m_j\theta + k - (q_j + a)K_j - aK_i = \frac{1+\lambda-\alpha_j}{1+\lambda}\left[m_j + \frac{m_i a K'_i(\theta)}{aK'_j(\theta) - m_i} \right](\check{\theta}_j - \theta), \qquad \#$$

where $i,j = 1,2$, $i \neq j$. We seek linear solutions $K_j(\theta) = L_j + K'_j\theta$, $j = 1,2$. The six parameters that characterize the solutions, i.e., $(L_j, K'_j, \check{\theta}_j)$, $j = 1,2$, must then satisfy

$$m_j - (q_j + a)K'_j - aK'_i = -\frac{1+\lambda-\alpha_j}{1+\lambda}\left[m_j + \frac{m_i a K'_i}{aK'_j - m_i} \right], \qquad \#$$

$$k - (q_j + a)L_j - aL_i = \frac{1+\lambda-\alpha_j}{1+\lambda}\left[m_j + \frac{m_i a K'_i}{aK'_j - m_i} \right]\check{\theta}_j, \qquad \#$$

where $i,j = 1,2$, $i \neq j$. (The system thus consists of four equations.) Note from (ref: E1) that the slopes of the equilibrium schedules are independent of $\check{\theta}_1, \check{\theta}_2$, and therefore the same as in the case of no outside option. An equilibrium as described in Proposition 3 must in addition satisfy $\pi(\bar{\theta}) = n(\bar{\theta})$ and $\pi(\underline{\theta}) = n(\underline{\theta})$, hence we must have $n(\bar{\theta}) - n(\underline{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \frac{\partial \Pi}{\partial \theta} d\theta$, i.e.,

$$n(\bar{\theta}) - n(\underline{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \sum_{j=1}^{2} m_j(L_j + K_j'\theta + h)d\theta = \sum_{j=1}^{2} m_j\Big[\,(L_j + h) + K_j'\frac{1}{2}\,\Big]. \qquad \#$$

We see that we have five equations and six unknowns. The following result is now a direct corollary to Proposition 3.

Corollary *If there are parameters* $(L_j, K_j', \check{\theta}_j)$, $j = 1,2$, *with* $\check{\theta}_j \in (\underline{\theta}, \bar{\theta})$ *that satisfy (ref: imp , ref: E1 , ref: E2 , ref: F1) and for which* (i) $\pi(\theta) = \int_{\underline{\theta}}^{\theta} \sum_{j=1}^{2} m_j(L_j + K_j'\theta' + h)d\theta' + n(\underline{\theta})$ *satisfies* $\pi(\theta) > n(\theta)$ *for all* $\theta \in (\underline{\theta}, \bar{\theta})$, *and* (ii) $G_j(k_j, \theta, \check{\theta}_j)$ *defined by (ref: GJ) is quasiconcave in* k_j *for all* θ, *then the investment profiles* $K_j(\theta) = L_j + K_j'\theta$, $j = 1,2$ *constitute a common agency equilibrium.*

Note that a sufficent (but by no means necessary) condition for $\pi(\theta) > n(\theta), \theta \in (\underline{\theta}, \bar{\theta})$, is that the outside value is 'strongly convex'; $n''(\theta) > \pi''(\theta)$, i.e., $n''(\theta) > m_1K_1' + m_2K_2'$.

Whether an equilibrium of the form given in Corollary 6 exists, depends in part on whether the equations (ref: E1) for the slope parameters do have appropriate solutions. A result concerning existence of such solutions was given in Olsen and Osmundsen (1998). To state that result, define $Q_j = \frac{m_i}{m_j}(\frac{q_j}{a} + 1) = \frac{\Pi_{i\theta}}{\Pi_{j\theta}}\frac{\Pi_{jj}}{\Pi_{12}}$, $\gamma_j = 1 - \frac{\alpha_j}{1+\lambda}$, and note that the assumption that the first-best investment schedules are increasing in the firm's efficiency parameter amounts to assuming $Q_j > 1, j = 1,2$. The following then holds.

Proposition (i) *For* $Q_j > 1, j = 1,2$, *equations (ref: E1) admit solutions* $K_j', j = 1,2$ *that satisfy* $0 < \frac{a}{m_i}K_j' < 1$ *if and only if* $\gamma_j < \frac{Q_j - 1}{Q_i - 1}(Q_i + \gamma_i)$, $i,j = 1,2$, $i \neq j$. *Any such solution pair* (K_1', K_2') *is then unique and satisfies* $\frac{a}{m_2}K_1' + \frac{a}{m_1}K_2' \leq 1$, *so the common-implementability conditions hold. Moreover:* $\frac{\partial K_j'}{\partial \alpha_j} < 0, \frac{\partial K_j'}{\partial \alpha_i} > 0$ *and* $\frac{\partial K_j'}{\partial \lambda} > 0$.
(ii) *For* $\gamma_j \leq Q_j - 1$, *the function* $G_j(k_j, \theta, \check{\theta}_j)$ *defined by (ref: GJ) with* $K_j(\theta) = L_j + K_j'\theta$, $j = 1,2$ *is quasiconcave in* k_j *for all* $\theta, \check{\theta}_j \in [\underline{\theta}, \bar{\theta}]$.

Part (i) is taken from Olsen and Osmundsen (1998). A proof of part (ii) is given in the appendix. The conditions on owner shares and technology (represented by γ_j and Q_j) in (ii) are stronger than those given in (i). footnote If technologies are symmetric, and hence $Q_1 = Q_2 = \frac{q}{a} + 1$, the conditions in (i) hold for any distribution of owner shares, while the conditions in (ii) hold whenever $\frac{\alpha_j}{1+\lambda} \geq 1 - \frac{q}{a}$. The latter always hold if $\frac{q}{a} \geq 1$, i.e. if $\frac{\Pi_{11}}{\Pi_{12}} \geq 2$.

As discussed in the previous section, it is of interest to know if the equilibrium investments for the common-agency game where the principals offer revelation mechanisms, are also equilibrium investments for the game where the principals offer tax functions. The following affirmative result is proved in the appendix. footnote

Proposition *Suppose* $Q_j > 1$ *and* $\gamma_j \leq \frac{Q_j - 1}{Q_i - 1}Q_i$, $i,j = 1,2$, $i \neq j$, *and let* $K_j', j = 1,2$ *be the unique solutions to (ref: E1) that satisfy (ref: imp). Suppose there are parameters* $(L_j, \check{\theta}_j)$, $j = 1,2$, *with* $\check{\theta}_j \in (\underline{\theta}, \bar{\theta})$ *that satisfy (ref: E2 , ref: F1) and for which* $\pi(\theta) = \int_{\underline{\theta}}^{\theta} \sum_{j=1}^{2} m_j(L_j + K_j'\theta' + h)d\theta' + n(\underline{\theta})$ *satisfies* $\pi(\theta) > n(\theta)$ *for all* $\theta \in (\underline{\theta}, \bar{\theta})$. *The investment profiles* $K_j(\theta) = L_j + K_j'\theta$, $j = 1,2$ *are then the equilibrium outcome of the game where the principals offer differentiable tax functions* $R_j(K_j), j = 1,2$. *The equilibrium tax functions are given by* (a) $R_j'(K_j)$ *satisfies (ref: txic) for* $K_j \in [K_j(\underline{\theta}), K_j(\bar{\theta})]$, (b) $R_j'(K_j) = R_j'(K_j(\underline{\theta}))$ *for* $K_j \leq K_j(\underline{\theta})$, (c) $R_j'(K_j) = R_j'(K_j(\bar{\theta}))$ *for* $K_j \geq K_j(\bar{\theta})$, *and* (d) $\Pi(K_1(\underline{\theta}), K_2(\underline{\theta}), \underline{\theta}) - \sum_{j=1}^{2} R_j(K_j(\underline{\theta})) \;\; = n(\underline{\theta})$.

While the slopes K_j' of the equilibrium schedules are uniquely determined under the conditions given in the last two propositions, we noted above that there are only five equations to determine the six parameters that characterize the equilibrium schedules. This leaves one degree of freedom, and we must therefore expect that these schedules are not uniquely determined. In fact, suppose we have an equilibrium solution $(L_j, K_j', \check{\theta}_j), j = 1,2$. According to (ref: F1), the solution must satisfy $m_1 L_1 + m_2 L_2 = M$, where M is a uniquely determined constant. We can then construct a new solution by letting the new intercepts satisfy this relation, and solve for the new $\check{\theta}_j$-parameters from (ref: E2). (This is feasible, at least for small variations in the intercept parameters.) This proves the first part of the following proposition.

Proposition *Suppose the assumptions of Corollary* 5 *and Proposition* 6 *or* 7 *hold. Then,* (i) *although the slopes* K_j' *of the equilibrium schedules are unique, the other parameters* $(L_j, \check{\theta}_j)$, *and hence the equilibria, are generally not unique. All such equilibria do satisfy* $m_1 L_1 + m_2 L_2 = const,$ *where the constant is uniquely determined.*
(ii) *Despite the non-uniqueness of equilibrium investments, equilibrium profits* $\pi(\theta)$ *are uniquely determined.*

To verify part (ii), note that $\pi'(\theta) = \frac{\partial \Pi}{\partial \theta} = \sum \frac{\partial N_j}{\partial \theta} = \sum m_j \left(L_j + K_j' \theta + h\right)$. Since the last sum is uniquely determined and $\pi(\underline{\theta})$ is given, we se that $\pi(\theta)$ is uniquely determined for all θ, as was to be shown. We next consider equilibrium tax revenues and welfare.

Proposition *Suppose the assumptions of Corollary* 5 *and Proposition* 6 *or* 7 *hold. Then neither total tax revenues nor total welfare are generally unique across all* (*linear*) *equilibria. The equilibrium with the highest total expected revenue and total expected welfare is characterized by* (*ref: F1*) *and*

$$(Q_1 - 1)\frac{a}{m_2}(L_1 + \tfrac{1}{2}K_1') - (Q_2 - 1)\frac{a}{m_1}(L_2 + \tfrac{1}{2}K_2') = \frac{k}{m_1} - \frac{k}{m_2}.$$

If the countries are fully symmetric, the symmetric equilibrium is thus the Pareto-preferred one. If the countries are symmetric with respect to technologies, but one country, say country 1 *has a larger owner share* $(\alpha_1 > \alpha_2)$, *the Pareto-preferred equilibrium has* $L_1 > L_2$, $K_1' < K_2'$, *and* $L_1 + \frac{1}{2}K_1' = L_2 + \frac{1}{2}K_1'$, *thus* $K_1(\theta) \gtreqless K_2(\theta)$ *as* $\theta \lesseqgtr \frac{1}{2}$.

The *proof* of this proposition is given in the appendix. Note that the last statement in the proposition implies that if the countries are technologically symmetric, but one country has a larger owner share, then the Pareto-preferred equilibrium has higher investments in that country for low-efficiency types, and higher investments in the other country for high-efficiency types. The equilibrium schedules for the two countries cross each other at $\theta = \frac{1}{2}$ (the midpoint of the type interval). Moreover, the investment level at the crossing point stays fixed as owner shares vary; this follows from (ref: F1). Hence, for fixed and symmetric technologies, as owner shares vary, the two investment schedules in the Pareto preferred equilibrium rotate in opposite directions around the fixed investment level corresponding to $\theta = \frac{1}{2}$.

It is of interest to compare resource allocations under the cooperative and the non-cooperative tax regimes. The next proposition contains comparative results for the fully symmetric case. Its proof is given in the appendix.

Proposition *In the quadratic-uniform case, for fully symmetric countries, and for a sufficiently convex outside value function* $n(\theta)$, *there is a critical number* $\Psi < 1$, *determined by technology* $(\Psi = 1/(1 + \frac{q}{4a}), \frac{q}{a} = \frac{\Pi_{11}}{\Pi_{12}} - 1)$, *such that for* $\frac{\alpha_1+\alpha_2}{1+\lambda} > \Psi$ *we have*: *The firm's profits are for all types* $\theta \in (\underline{\theta}, \bar{\theta})$ *lower when the countries compete than when they cooperate. Hence, the IR constraint for type* $\bar{\theta}$ *is either* (i) *binding in both regimes,* (ii) *binding only in the competitive regime, or* (iii) *non-binding for both regimes. Investments are in case* (iii) *lower for all types* (*but type* $\bar{\theta}$) *under competition compared to cooperation. In cases* (i) *and* (ii), *investments under competition are* (*in the symmetric equilibrium*) *lower for inefficient types* (*all* $\theta < \tilde{\theta}$, *some* $\tilde{\theta} < \bar{\theta}$) *and higher for efficient types* $(\theta > \tilde{\theta})$ *compared to investments under cooperation.*
For $\frac{\alpha_1+\alpha_2}{1+\lambda} < \Psi$ *the converse conclusions hold. footnote*

The proposition confirms the intuition that the firm's profits are lower (higher) in the competitive regime when the 'inside' owner share $\alpha_1 + \alpha_2$ is large (small). Figure 1 illustrates the investment comparisons for the case of 'large' $\alpha_1 + \alpha_2$. The conditions in the proposition can also be related to the ease with which capital can be substituted between the two countries. The elasticity of substitution between K_1 and K_2 for the firm's symmetric pre-tax profit function $\Pi(K_1, K_2, \theta)$, evaluated at the point $K_1 = K_2 = \frac{1}{2}K_F(\theta)$, where $K_F(\theta)$ is the first-best investment in each country, is $\sigma = \frac{2a}{q} + 1$. footnote In view of this, the last proposition says that the firm's rents are lower under competition compared to cooperation if and only if the elasticity of substitution is sufficiently small ($\sigma = \frac{2a}{q} + 1 < \frac{1+\lambda-\alpha_i}{1+\lambda-2\alpha_i}$). Thus, it is when substitution is difficult ($\frac{a}{q}$ small) that the firm is worse off when the countries compete compared to when they cooperate.

We finally consider comparative statics effects of variations in the outside value for the firm. This analysis is complicated by the fact that the equilibrium in principle depends on the whole profile of outside values (over all types), and hence that the exercise in general should involve comparisons of all such profiles. We limit ourselves to profiles that generate the type of equilibrium studied above, i.e. where the participation constraints are binding only for the most effcient and least efficient types. Among other things we will show that if $n^1(\theta)$ and $n^2(\theta)$ are two such profiles, and $n^1(\theta) \geq n^2(\theta)$, then under competition it may be the case that the higher profile $n^1(\theta)$ yields a greater social surplus than the lower profile $n^2(\theta)$. Hence all parties may gain when the firm's outside option becomes more favorable! This will *not* occur when the countries cooperate, since the higher profile implies a striciter set of participation constraints and therefore if anything a lower total surplus.

All else equal (technology, owner shares etc.) an equilibrium of the form studied in this paper is determined by the outside option values for the most efficient and the least efficent types of the firm, or more precisely by the difference $n(\bar{\theta}) - n(\underline{\theta})$. (See Corollary 5) This single number, which we will denote by η, determines how the equilibrium depends on the outside value profile. Normalizing $n(\underline{\theta}) = 0$, we have $\eta = n(\bar{\theta})$. Such an equilibrium is only feasible for η in some range (η_1, η_2). The lower bound η_1 of this range is the rent that would accrue to the best type in the conventional case with type-independent reservation profit. This corresponds to the case $\check{\theta}_1 = \check{\theta}_2 = \bar{\theta}$ in our model. The upper bound η_2 is the profit that would accrue to the best type if on the other hand $\check{\theta}_1 = \check{\theta}_2 = \underline{\theta}$.

For η in this range, the firm's equilibrium profit is unique and given by a convex function $\pi(\theta; \eta)$. Here η is used as an indexing parameter; we have $\pi(\bar{\theta}; \eta) = \eta$. Note that any outside value profile that satisfies $n(\underline{\theta}) = \pi(\underline{\theta}; \eta) = 0$, $n(\bar{\theta}) = \pi(\bar{\theta}; \eta) = \eta$, and $n(\theta) \leq \pi(\theta; \eta)$, will generate such an equilibrium. Let $N(\eta)$ denote the family of all such profiles. Formally

Definition. *For η in (η_1, η_2), let $N(\eta)$ be the family of all outside value profiles that satisfy $n(\underline{\theta}) = 0$, $n(\bar{\theta}) = \eta$ and $n(\theta) \leq \pi(\theta; \eta)$, where $\pi(\theta; \eta)$ is (uniquely) given by $\pi(\theta; \eta) = \int_{\underline{\theta}}^{\theta} \frac{\partial \Pi}{\partial \theta}(K_1(\theta'), K_2(\theta'), \theta')d\theta'$, $\pi(\bar{\theta}; \eta) = \eta$, and $K_j(\theta) = L_j + K_j'\theta$, $j = 1, 2$. satisfy (ref: imp), (ref: E1) and (ref: E2) with $\check{\theta}_j \in (\underline{\theta}, \bar{\theta})$, $j = 1, 2$.*

We will study how the equilibrium outcome associated with an outside value profile in the family $N(\eta)$ varies when η varies on the interval (η_1, η_2). Each profile in $N(\eta)$ yields equilibrium profits $\pi(\theta; \eta)$, and this function is increasing in η. A more favorable outside option, in the sense of one that yields an outside value that is higher for the best type (η) and that belongs to the corresponding family $N(\eta)$, will thus lead to equilibrium profits that are more favorable for every type of firm.

Proposition *Consider the case of fully symmetric countries (including $\alpha_1 = \alpha_2$). There is number $\Psi < 1$, determined by technology ($\Psi = 1/(1 + \frac{q}{4a})$), such that for $\frac{\alpha_1+\alpha_2}{1+\lambda} > \Psi$ (respectively $\frac{\alpha_1+\alpha_2}{1+\lambda} < \Psi$) we have: For the family $N(\eta)$ it is the case that, as η (the outside value for the best type) increases on (η_1, η_2), the total value $E(W_1 + W_2)$ associated with the symmetric non-cooperative equilibrium first increases and then decreases (respectively decreases over the whole interval). In any case, every type of firm benefits as η increases.*

A *proof* is given in the appendix. The proposition shows that the total surplus under competition is either (i) first increasing and then decreasing, or (ii) monotone decreasing in the firm's outside value index η. More favorable outside opportunities for the firm will thus in some cases improve the social surplus, although only up to some point. Note also that the condition that defines case (i) ($\frac{\alpha_1+\alpha_2}{1+\lambda} > \Psi$), is the same condition that makes the competitive tax regime less attractive for the firm than the cooperative regime. Since the surplus under cooperation will if anything decline as η increases, we see that the relative performance of the competitive regime will in this case improve as the firm's outside opportunities become better. The total benefits of cooperation may thus well be smaller when the MNE has attractive outside opportunities (e.g. in third-country tax havens) than the benefits that can be obtained when the MNE has no such opportunities at all.

Conclusion

In the short run, the effective tax rates imposed on national firms may be higher than in neighbouring countries. There may be several reasons for this. First, investments may be subject to mobility costs, i.e., existing investments may be partly irreversible (locked-in). Second, predominantly national firms may have relatively low profitability abroad, e.g., due to lack of international business experience. To attract new investments, however, national tax rates will have to be competitive. Due to superior infrastructure, the EU-countries may attract investments at higher effective tax rates than tax havens or low cost countries. Still, for many industries outside options impose an upper limit to EU corporate tax rates.

We analyse a case where an MNE allocates investments between two countries (the home region), while also having an outside investment option. The two counrties in the home region competes to attract the firm's investments and to tax the firm. The firm has private information about its efficiency and the net operating profits in the two countries, and about the value of the outside investment option. To reduce its tax burden, the MNE has an incentive to report a low productivity in the home region, thus understating the tax base. At the same time it would like to induce the governments in the home region to reduce its taxes by implicitly threatening to move all or parts of its activity to another economic region. Thus the firm has an incentive to overstate its productivity on outside investments, i.e., it would like to exaggerate the value of its outside option (which may be a proxy for its international mobility). However, the productivity in the home region and the foreign region are likely to be correlated. Thus, the MNE faces countervailing incentives: it cannot at the same time claim to be efficient and inefficient.

The equilibrium investment schedules of the game are non-unique. Contrary to the cooperative case, the non-cooperative case leaves one degree of freedom for the equilibrium solution. This also applies when the countries are symmetrical in all respects, i.e., there are non-symmetric investment equilibria when the countries are symmetric. The Pareto-preferred equilibrium, however, is shown to be unique and symmetric. In the symmetric equilibrium there is significant underinvestments (relative to the first best) for firms with low efficiency. If the participation constraint is binding for the most efficient type, there is overinvestment for the more efficient types. Tax competition may increase or decrease the firm's rents, relative to tax coordination. A higher value of the outside option is beneficial for the firm, and detrimental to the governments if they cooperate. However, the countries may be positively affected by a higher outside option if they compete.

Our focus is taxation of internationally mobile firms, where mobility and asymmetric information poses serious challenges to the tax authorities. Hence, similar to other papers in this field footnote , our analytical focus is on source taxes, i.e., corporate income taxes and withholding taxes, or a two-level tax system with full imputation. Thus, the taxes in the primal formulation of the problem, r_1 and r_2 in Eq. (2), are source taxes. footnote However, as a means for implementing the optimal investment allocation, both source taxes and residence taxes may be applied. Note, though, that our approach is partial, i.e., we do not account for issues of equity which are essential to personal income tax design.

The two countries compete to attract the investments of an MNE. The tax literature normally assumes that any one firm is too small to affect tax policy in a jurisdiction. We assume that the MNE is a large and unique firm, or that the jurisdictions are small, so that the potential tax revenues from the firm is non-negligible relative to the corporate tax bases of the two jurisdictions. An alternative interpretation is that the tax subject in the model is a mobile industry.

The tax schedules we derive for the two countries are non-linear functions of investment levels. As shown by Laffont and Tirole (1986, 1993), such non-linear tax schedules can alternatively be implemented by a menu of linear tax contracts, generated by investment fees and lump sum taxes. Furthermore, as shown by Osmundsen et al. (1998) the optimal tax contract can be given an alternative design that is more similar to actual tax regimes, in the sense that it reflects more accurately the type of information usually available and the type of instruments governments actually use. Most countries tax firms by means of a corporate income tax system. The corporate income tax base is often a non-linear function of the firm's investments, due to non-linear deductible capital allowances and possibly a tax-exempt income. Osmundsen et al. show (for the single country case) that an optimal investment solution with information-induced distortions can be implemented within a corporate income tax system, by offering the firm tax base adjustments in the form of a capital allowance as a function of the firm's investments, and in addition a tax exempt income. footnote Information-induced investment distortions are implemented by designing capital allowances that deviate from true economic depreciation and the financial opportunity cost of the invested capital.

The model is somewhat related to the policy discussion about whether countries should encourage national firms to invest abroad, or whether they should induce them to stay at home. This question could be addressed by an interesting extension of the model; by endogenising the outside option. It could also be interesting to examine dynamic aspects of the model. For example, analogous to the assumptions made in a single-principal model of Osmundsen (1997), we may assume that the efficiency of operations in the foreign region is determined by a learning-by-doing process, in which case the second-period productivity in foreign operations is a function of foreign investments in the first period. In designing first-period incentives for the firm, the governments in the home region would have to take into account how these incentives will affect the outside options - and thereby the bargaining position of the governments - in the second period.

We have assumed that the firm has private information about its operating profits and about its efficiency level. The investment levels are assumed to be subject to symmetric information. Observability of investments may be a reasonable description for physical capital, but not to the same extent for intangible assets. The latter may be important for MNEs, since they typically have high levels of R&D relative to sales. footnote Also, we assume that the MNE's efficiency levels are perfectly correlated in the countries of operation. Uncorrelated efficiency parameters, however, may be relevant if firms invest in different countries to diversify portfolios. footnote Asymmetric information about investment levels, or uncorrelated information parameters, may represent interesting extensions of the present model. However, each of these extensions would imply a multidimensional screening problem (i.e., a challenge for the government to reveal a vector of parameters subject to private information), which is not yet fully solved, not even in a single-principal setting; see Rochet and Chone (1998).

appendix

Appendix

Simultaneous investments in all regions.

Consider the case where the MNE may operate also in the 'outside' country. The tax autorities in this country are assumed to be passive. We can then interpret the pre-tax return function $\Pi(K_1,K_2,\theta)$ in (ref: P) as a 'reduced form' profit function that is the relevant one for the firm's operations in countries 1 and 2. To see this, let pre-tax profits for the firm when it is active in all three countries be given by $\tilde{\Pi}(K_1,K_2,K_3,\theta)$. For any given investments K_1,K_2 in the two 'inside' countries, the firm will choose its investments in the outside country so as to maximize $\tilde{\Pi}(K_1,K_2,K_3,\theta)$. We can then simply let $\Pi(K_1,K_2,\theta)$ be defined as the maximum value function; $\Pi(K_1,K_2,\theta) = \max_{K_3}\tilde{\Pi}(K_1,K_2,K_3,\theta)$. Under reasonable assumptions regarding $\tilde{\Pi}(K_1,K_2,K_3,\theta)$, the indirect or reduced form function $\Pi(K_1,K_2,\theta)$ will have the properties assumed in the main text.

The outside value is obtained when the firm completely withdraws from countries 1 and 2. We assume that the firm in that case is able to use an alternative technology that yields profits given by some function $\hat{\Pi}(K_3,\theta)$. For example, the firm may be able to better exploit economies of scale or scope. The outside value is then $n(\theta) = \max_{K_3}\hat{\Pi}(K_3,\theta)$, and under reasonable conditions the outside value will be increasing and convex in θ. For the kind of equilibria we consider in this paper (where participation constraints are binding only for the least efficient and the most efficient types), the outside value should be 'sufficiently convex'. For example, as one of a set of sufficient conditions we may assume the outside value to be more convex than the inside rent, i.e. $n''(\theta) > \pi''(\theta)$. The inside profit (rent) function will by incentive compatibility –under cooperation as well as non-cooperation–satisfy $\pi'(\theta) = \frac{\partial\Pi}{\partial\theta}(K_1(\theta),K_2(\theta),\theta)$, see (ref: IC), where $K_1(\theta),K_2(\theta)$ are the equilibrium 'inside' investments. Since $K_1(\theta),K_2(\theta)$ and therefore $\pi(\theta)$ and its curvature are determined by the properties of the function $\tilde{\Pi}()$, while $n(\theta)$ and its curvature are determined by the (different) function $\hat{\Pi}()$, there are clearly constellations of these functions that make $n(\theta)$ more convex than $\pi(\theta)$.

Proof of Proposition 1:

Taking account of (ref: IC), use integration by parts to write the expected welfare $E(W_1 + W_2)$ as

$$(1+\lambda)\int_{\underline{\theta}}^{\bar{\theta}}\left\{\Pi(\tilde{K}_1(\theta),\tilde{K}_2(\theta),\theta) - (1-\frac{\alpha_1+\alpha_2}{1+\lambda})\frac{\partial\Pi}{\partial\theta}\left(\tilde{K}_1(\theta),\tilde{K}_2(\theta),\theta\right)\frac{F(\check{\theta})-F(\theta)}{f(\theta)}\right\}dF(\theta)$$
$$-(1+\lambda-\alpha_1-\alpha_2)\left\{\tilde{\pi}(\underline{\theta})F(\check{\theta}) + \tilde{\pi}(\bar{\theta})\left[1-F(\check{\theta})\right]\right\},$$

where $\tilde{K}_1(\theta),\tilde{K}_2(\theta),\tilde{\pi}(\theta)$ is any incentive compatible investment-profits combination. Conditions (a,b,c) guarantee that the last term is minimal for $\tilde{\pi} = \pi$ for each possible value of $\check{\theta}$. The definition of $K_1(\theta),K_2(\theta)$ guarantees that the first term (the integral) is maximal. Since all IC and IR constraints are fulfilled, this solution must be optimal.

To prove the statement regarding tax revenues, note that by incentive compatibility we have $\Sigma r_j'(\theta) = \Sigma\frac{\partial\Pi}{\partial K_j}K_j'(\theta)$. From (ref: CO)we see that the last sum has the same sign as $\check{\theta}-\theta$. This proves the statement.

Proof of Lemma:

Suppose principal i offers the mechanism $K_i(\theta),r_i(\theta)$. Then by assumption $K_j(\theta),r_j(\theta)$ is a feasible (incentive compatible and individually rational) mechanism for principal j. We need to show that it is also optimal for principal j. Let $\tilde{K}_j(\theta),\tilde{r}_j(\theta)$ be any incentive compatible and individually rational mechanism, and define $\tilde{\pi}(\hat{\theta}_j,\hat{\theta}_i,\theta) \equiv \Pi\left(\tilde{K}_j(\hat{\theta}_j),K_i(\hat{\theta}_i),\theta\right) - \tilde{r}_j(\hat{\theta}_j) - r_i(\hat{\theta}_i)$. Then, for every θ there is $\tilde{\theta}_i = \tilde{\theta}_i(\theta)$ such that $\tilde{\pi}(\theta,\tilde{\theta}_i,\theta) \geq \tilde{\pi}(\hat{\theta}_j,\tilde{\theta}_j',\theta)$ for all feasible reports $\hat{\theta}_j,\tilde{\theta}_i'$, and moreover $\tilde{\pi}(\theta,\tilde{\theta}_i,\theta) \geq n(\theta)$. It follows that $\tilde{\theta}_i(\theta) = \hat{\theta}_i(\tilde{K}_j(\theta),\theta)$, where $\hat{\theta}_i()$ is the best response defined in the lemma, and that the agent's maximal profit $\tilde{\pi}(\theta) = \tilde{\pi}(\theta,\tilde{\theta}_i(\theta),\theta)$ satisfies

$$\tilde{\pi}'(\theta) = \frac{\partial\Pi}{\partial\theta}(\tilde{K}_j(\theta),K_i(\hat{\theta}_i(\tilde{K}_j(\theta),\theta),\theta) \qquad \#$$

After an integration by parts, principal j's payoff can then be written as

$$EW_j = \int_{\underline{\theta}}^{\bar{\theta}} \Big\{ (1+\lambda)\Big(\Pi(\tilde{K}_j(\theta), K_i(\hat{\theta}_i(\tilde{K}_j(\theta),\theta)),\theta) - r_i(\hat{\theta}_i(\tilde{K}_j(\theta),\theta))\Big)$$

$$- (1+\lambda-\alpha_j)\frac{\partial \Pi}{\partial \theta}(\tilde{K}_j(\theta), K_i(\hat{\theta}_i(\tilde{K}_j(\theta),\theta)),\theta)\frac{F(\check{\theta}_j)-F(\theta)}{f(\theta)}\Big\} dF(\theta)$$

$$- (1+\lambda-\alpha_j)\Big\{\tilde{\pi}(\bar{\theta})\big[1-F(\check{\theta}_j)\big] + \tilde{\pi}(\underline{\theta})F(\check{\theta}_j)\Big\}.$$

Note that (by CIC) we have $\Pi(K_j(\theta), K_i(\hat{\theta}_i),\theta) - r_i(\hat{\theta}_i) \leq \Pi(K_j(\theta), K_i(\theta),\theta) - r_i(\theta)$, so we may write

$$\Pi(\tilde{K}_j, K_i(\hat{\theta}_i),\theta) - r_i(\hat{\theta}_i) \leq \Pi(\tilde{K}_j, K_i(\hat{\theta}_i),\theta) - \Pi(K_j(\theta), K_i(\hat{\theta}_i),\theta)$$
$$+ \Pi(K_j(\theta), K_i(\theta),\theta) - r_i(\theta)$$

From the assumption (regarding G_j) in the lemma, we then see that the integrand is maximal for $\tilde{K}_j(\theta) = K_j(\theta)$. Moreover, the rents in the last term of EW_j are minimal for $\tilde{K}_j(\theta) = K_j(\theta)$, and all IR conditions are satisfied. This shows that $K_j(\theta)$ is an optimal response for principal j. QED.

Proof of formula (ref: DK):

The FOC for $\hat{\theta}_i$ is $\frac{\partial \Pi}{\partial K_i}\big(K_j, K_i(\hat{\theta}_i),\theta\big)K_i'(\hat{\theta}_i) = r_i'(\hat{\theta}_i)$. From CIC we have $r_i'(\theta) = \frac{\partial \Pi}{\partial K_i}(K_j(\theta), K_i(\theta),\theta)K_i'(\theta)$ for all θ, and hence, when $K_i' \neq 0$; $\frac{\partial \Pi}{\partial K_i}\big(K_j, K_i(\hat{\theta}_i),\theta\big) = \frac{\partial \Pi}{\partial K_i}\big(K_j(\hat{\theta}_i), K_i(\hat{\theta}_i),\hat{\theta}_i\big)$, where $\hat{\theta}_i = \hat{\theta}_i(K_j,\theta)$. Differentiating this relation w.r.t. K_j, and evaluating the result at $K_j = K_j(\theta)$ and (by CIC) $\hat{\theta}_i = \theta$, we obtain the formula (ref: DK). QED.

Proof of Proposition 6 (ii).

Consider first the firm's response $\hat{\theta}_i(k_j,\theta)$ as defined in the lemma. Let $\underline{k}_j(\theta)$ and $\bar{k}_j(\theta)$ be defined by $\frac{\partial \Pi}{\partial K_i}\big(\bar{k}_j(\theta), K_i(\underline{\theta}),\theta\big) = \frac{\partial \Pi}{\partial K_i}(K_j(\underline{\theta}), K_i(\underline{\theta}),\underline{\theta})$ and $\frac{\partial \Pi}{\partial K_i}(\underline{k}_j(\theta), K_i(\bar{\theta}),\theta) = \frac{\partial \Pi}{\partial K_i}(K_j(\bar{\theta}), K_i(\bar{\theta}),\bar{\theta})$, respectively. Using $r_i'(\theta) = \frac{\partial \Pi}{\partial K_i}(K_j(\theta), K_i(\theta),\theta)K_i'$ in conjunction with (ref: imp), we find that the firm's best report $\hat{\theta}_i$ is given by

$\hat{\theta}_i = \underline{\theta}$ if $k_j \geq \bar{k}_j(\theta) = K_j(\underline{\theta}) + \frac{m_i}{a}(\theta - \underline{\theta})$
$\hat{\theta}_i = \bar{\theta}$ if $k_j \leq \underline{k}_j(\theta) = K_j(\bar{\theta}) + \frac{m_i}{a}(\theta - \bar{\theta})$
$\hat{\theta}_i = \theta - \frac{a}{m_i}(k_j - K_j(\hat{\theta}_i))$, i.e. by $\frac{\partial \Pi}{\partial K_i}(k_j, K_i(\hat{\theta}_i),\theta) = \frac{\partial \Pi}{\partial K_i}(K_j(\hat{\theta}_i), K_i(\hat{\theta}_i),\hat{\theta}_i)$ o.w.

Note that (ref: imp) implies $\underline{k}_j(\theta) \leq K_j(\theta) \leq \bar{k}_j(\theta)$, and that $\hat{\theta}_i = \theta$ if and only if $k_j = K_j(\theta)$. Note also that for $K_i(\hat{\theta}_i(k_j,\theta))$ we have, in accordance with (ref: DK) $\frac{\partial K_i}{\partial k_j} = \frac{-aK_i'}{m_i - aK_j'} = \frac{\Pi_{12}K_i'}{\Pi_{i\theta}+\Pi_{12}K_j'}$ for $\underline{k}_j(\theta) < k_j < \bar{k}_j(\theta)$.

Consider next $G_j()$, and let $\underline{k}_j(\theta) < k_j < \bar{k}_j(\theta)$. We have then (due to the optimality condition for $\hat{\theta}_i(k_j,\theta)$)

$$\frac{\partial G_j}{\partial k_j}(k_j,\theta;\check{\theta}_j) = \frac{\partial \Pi}{\partial K_j}(k_j, K_i(\hat{\theta}_i(k_j,\theta)),\theta) - \frac{1+\lambda-\alpha_j}{1+\lambda}\Big(\frac{\partial^2 \Pi}{\partial \theta \partial k_j} + \frac{\partial^2 \Pi}{\partial \theta \partial K_i}\frac{\partial K_i}{\partial k_j}\Big)\frac{F(\check{\theta}_j)-F(\theta)}{f(\theta)}$$

and hence

$$\frac{\partial^2 G_j}{\partial k_j^2} = \frac{\partial^2 \Pi}{\partial K_j^2} + \frac{\partial^2 \Pi}{\partial K_j \partial K_i}\frac{\partial K_i}{\partial k_j} = -(q_j + a) - a\frac{-aK_i'}{m_i - aK_j'} \leq -(q_j+a) + a < 0,$$

where the first inequality follows from the implementability conditions (ref: imp): we have $m_i - aK_j' \geq aK_i'$. Hence $G_j()$ is strictly concave in k_j on this interval, and has a uniqe local maximum there.

Consider next $k_j > \bar{k}_j(\theta)$. Here $\hat{\theta}_i(k_j,\theta) = \underline{\theta}$, and so (since $\frac{\partial K_i}{\partial k_j} = 0$ here)

$$\frac{\partial G_j}{\partial k_j}(k_j,\theta;\check{\theta}_j) = \frac{\partial \Pi}{\partial K_j}(k_j, K_i(\underline{\theta}),\theta) - \frac{1+\lambda-\alpha_j}{1+\lambda}\frac{\partial^2 \Pi}{\partial \theta \partial K_j}\frac{F(\check{\theta}_j)-F(\theta)}{f(\theta)} \leq \frac{\partial G_j}{\partial k_j}(\bar{k}_j(\theta)^+,\theta;\check{\theta}_j)$$

where $\bar{k}_j(\theta)^+$ denotes a limit from above, and the inequality follows from $\frac{\partial G_j}{\partial k_j}$ being decreasing in k_j. The expression on the right hand side is non-increasing in θ: its derivative wrt θ is $\frac{\partial^2\Pi}{\partial K_j^2}\bar{k}_j' + \frac{\partial^2\Pi}{\partial\theta\partial K_j}(1+\gamma_j) = -(q_j+a)\frac{m_i}{a} + m_j(1+\gamma_j)$, which is nonpositive by the assumption $\gamma_j + 1 \leq Q_j$. Hence we have (explanations to follow)

$$\frac{\partial G_j}{\partial k_j}(\bar{k}_j(\theta)^+,\theta;\check{\theta}_j) \leq \frac{\partial G_j}{\partial k_j}(\bar{k}_j(\underline{\theta})^+,\underline{\theta};\check{\theta}_j) = \frac{\partial\Pi}{\partial K_j}(K_j(\underline{\theta}),K_i(\underline{\theta});\underline{\theta}) - \gamma_j\frac{\partial^2\Pi}{\partial\theta\partial K_j}(\check{\theta}_j - \underline{\theta}) \leq 0,$$

where the equality follows from $\bar{k}_j(\underline{\theta}) = K_j(\underline{\theta})$, and the inequality follows from (ref: DEQ , ref: DE1). This shows that $\frac{\partial G_j}{\partial k_j} \leq 0$ for $k_j > \bar{k}_j(\theta)$.

Consider finally $k_j \leq \underline{k}_j(\theta)$. Here $\hat{\theta}_i(k_j,\theta) = \bar{\theta}$, and by similar arguments we find

$$\frac{\partial G_j}{\partial k_j}(k_j,\theta;\check{\theta}_j) \geq \frac{\partial G_j}{\partial k_j}(\underline{k}_j(\bar{\theta})^-,\bar{\theta};\check{\theta}_j) = \frac{\partial\Pi}{\partial K_j}(K_j(\bar{\theta}),K_i(\bar{\theta}),\bar{\theta}) - \gamma_j\frac{\partial^2\Pi}{\partial\theta\partial K_j}(\check{\theta}_j - \bar{\theta}) \geq 0.$$

This allows us to conclude that $G_j()$ is quasiconcave in k_j and has a unique interior maximum.

Proof of Proposition 7

To simplify notation, let $\underline{K}_j = K_j(\underline{\theta})$ and $\bar{K}_j = K_j(\bar{\theta})$. Let $\pi^a(K_1,K_2,\theta) = \Pi(K_1,K_2,\theta) - R_1(K_1) - R_2(K_2)$ denote the after tax profit for the given tax functions. The marginal net profit in country i, given investments K_j in the other country, is then $\frac{\partial\pi^a}{\partial K_i} = \frac{\partial\Pi}{\partial K_i}(K_i,K_j,\theta) - \frac{\partial\Pi}{\partial K_i}(K_i,K_j(\theta_i(K_i)),\theta_i(K_i))$ if $\underline{K}_i \leq K_i \leq \bar{K}_i$, and $\frac{\partial\pi^a}{\partial K_i} = \frac{\partial\Pi}{\partial K_i}(K_i,K_j,\theta) - c$ otherwise, where $c = \frac{\partial\Pi}{\partial K_i}(\underline{K}_i,\underline{K}_j,\underline{\theta})$ if $K_1 < \underline{K}_i$, and $c = \frac{\partial\Pi}{\partial K_i}(\bar{K}_i,\bar{K}_j,\bar{\theta})$ if $K_i > \bar{K}_i$. Note that $\frac{\partial\pi^a}{\partial K_i}$ is continuous in both variables. We first show that the given tax functions implement $K_1(\theta),K_2(\theta)$.

The second-order derivatives are $\pi^a_{ii} = \Pi_{ii}$ and $\pi^a_{ij} = \Pi_{12}$ if $K_i < \underline{K}_i$ or $K_i > \bar{K}_i$; and $\pi^a_{ii} = -\Pi_{12}\frac{K_j'}{K_i'} - \Pi_{\theta i}\frac{1}{K_i'}$ and $\pi^a_{ij} = \Pi_{12}$ if $\underline{K}_i < K_i < \bar{K}_i$. The strict versions of the implementability conditions (ref: imp), and the assumptions $Q_j > 1$ imply that $\pi^a()$ is strictly concave. In particular, computing $H = \pi^a_{11}\pi^a_{22} - (\pi^a_{12})^2$ for $K_1 \in (\underline{K}_1,\bar{K}_1)$ and $K_2 \in (\underline{K}_2,\bar{K}_2)$, we find $H = (a\frac{K_2'}{K_1'} - \frac{m_1}{K_1'})(a\frac{K_1'}{K_2'} - \frac{m_2}{K_2'}) - a^2 = \frac{m_1m_2}{K_1'K_2'}(1 - \frac{a}{m_1}K_2' - \frac{a}{m_2}K_1') > 0$. Similar computations show that $H > 0$ for all K_1,K_2. Since $(K_1,K_2) = (K_1(\theta),K_2(\theta))$ satisfies the first-order condition for type θ, this investment combination is the optimal one for this type of firm.

To prove that the tax functions constitute an equilibrium, suppose country i offers the schedule $R_i(K_i)$. The revelation principle holds for principal j's problem. Let $\tilde{K}_j(\theta),\tilde{r}_j(\theta)$ be any incentive compatible and individually rational mechanism, and define $\tilde{\pi}(\hat{\theta}_j,K_i,\theta) = \Pi(\tilde{K}_j(\hat{\theta}_j),K_i,\theta) - \tilde{r}_j(\hat{\theta}_j) - R_i(K_i)$. Then, for every θ there is $\tilde{K}_i = \tilde{K}_i(\theta)$ such that (IC) $\tilde{\pi}(\theta,\tilde{K}_i,\theta) \geq \tilde{\pi}(\hat{\theta}_j,K_i,\theta)$ for all $\hat{\theta}_j,K_i$, and (IR) $\tilde{\pi}(\theta,\tilde{K}_i,\theta) \geq n(\theta)$ hold.

Define $\tilde{\Pi}(k_j,\theta) = \max_{K_i}[\Pi(K_i,k_j,\theta) - R_i(K_i)]$, and let $\hat{K}_i(k_j,\theta)$ be the maximizer, which, by strict concavity of the objective, is unique. It follows from (IC) that $\tilde{K}_i(\theta) = \hat{K}_i(\tilde{K}_j(\theta),\theta)$, and that the agent's maximal profit can be written as $\tilde{\pi}(\theta) \equiv \tilde{\pi}(\theta,\tilde{K}_i(\theta),\theta) = \tilde{\Pi}(\tilde{K}_j(\theta),\theta) - \tilde{r}_j(\theta)$. Moreover, by (IC) we also have $\tilde{\pi}'(\theta) = \frac{\partial\Pi}{\partial\theta}(\tilde{K}_j(\theta),\hat{K}_i(\tilde{K}_j(\theta),\theta),\theta)$. After an integration by parts, principal j's payoff can then be written as

$$EW_j = (1+\lambda)\int_{\underline{\theta}}^{\bar{\theta}}\tilde{W}_j(\tilde{K}_j(\theta),\theta,\check{\theta}_j)f(\theta)d\theta - (1+\lambda-\alpha_j)\{\tilde{\pi}(\bar{\theta})[1-F(\check{\theta}_j)] + \tilde{\pi}(\underline{\theta})F(\check{\theta}_j)\}$$

where

$$\tilde{W}_j(k_j,\theta,\check{\theta}_j) = \tilde{\Pi}(k_j,\theta) - \gamma_j\frac{\partial\Pi}{\partial\theta}(k_j,\hat{K}_i(k_j,\theta),\theta)\frac{F(\check{\theta}_j)-F(\theta)}{f(\theta)}$$

We next show that $\tilde{W}_j(k_j,\theta,\check{\theta}_j) \leq \tilde{W}_j(K_j(\theta),\theta,\check{\theta}_j)$ for all $k_j \geq 0$. Provided $K_j(\theta)$ is implementable and yields minimal rents to types $\bar{\theta}$ and $\underline{\theta}$, it is then clearly optimal.

To consider implementability, let $r_j(\theta) = R_j(K_j(\theta))$. Since $K_1(\theta),K_1(\theta)$ is optimal for firm θ for the given tax functions, we have

$\pi(\theta) \equiv \Pi(K_j(\theta),K_i(\theta),\theta) - R_j(K_j(\theta)) - R_i(K_i(\theta)) \geq \Pi(k_j,k_i,\theta) - R_j(k_j) - R_i(k_i)$ for all k_j,k_i, and $\pi(\theta) \geq n(\theta)$ with equality for $\theta = \bar{\theta}$ and $\theta = \underline{\theta}$. Hence $K_j(\theta)$ is implementable and it does yield minimal rents to types $\bar{\theta}$ and $\underline{\theta}$.

Consider then $\tilde{W}_j(k_j,\theta,\check{\theta}_j)$. Using the uniform distribution on $(0,1)$ and differentiating with respect to k_j we get

$$\frac{\partial \tilde{W}_j}{\partial k_j} = \frac{\partial \Pi}{\partial K_j}(\hat{K}_i, k_j, \theta) - \gamma_j(\Pi_{i\theta}\frac{\partial \hat{K}_i}{\partial k_j} + \Pi_{j\theta})(\check{\theta}_j - \theta)$$

Defining $\underline{k}_j(\theta)$ and $\bar{k}_j(\theta)$ as in the proof of Proposition 6 (i.e. by $\frac{\partial \Pi}{\partial K_i}(\bar{K}_i, \underline{k}_j(\theta), \theta) = \frac{\partial \Pi}{\partial K_i}(\bar{K}_i, \bar{K}_j, \bar{\theta})$ and by $\frac{\partial \Pi}{\partial K_i}(\underline{K}_i, \bar{k}_j(\theta), \theta) = \frac{\partial \Pi}{\partial K_i}(\underline{K}_i, \underline{K}_j, \underline{\theta})$) we find that $\hat{K}_i > \underline{K}_i$ when $k_j < \underline{k}_j(\theta)$, $\hat{K}_i < \bar{K}_i$ when $k_j > \bar{k}_j(\theta)$, and $\underline{K}_i < \hat{K}_i < \bar{K}_i$ otherwise. From the first-order condition $\frac{\partial \Pi}{\partial K_i}(\hat{K}_i, k_j, \theta) = R_i'(\hat{K}_i)$ we then find

$$\frac{\partial \hat{K}_i}{\partial k_j} = -\frac{\Pi_{12}}{\Pi_{ii}} = -\frac{a}{q_i + a} \qquad \text{for } k_j < \underline{k}_j(\theta) \text{ or } k_j > \bar{k}_j(\theta),$$

$$\frac{\partial \hat{K}_i}{\partial k_j} = \frac{\Pi_{12}K_i'}{\Pi_{12}K_j' + \Pi_{\theta i}} = \frac{aK_i'}{aK_j' - m_i} \qquad \text{for } k_j \in (\underline{k}_j(\theta), \bar{k}_j(\theta)).$$

The implementability conditions (ref: imp) and $Q_j > 1$ imply $\frac{\partial \hat{K}_i}{\partial k_j} > -\frac{m_j}{m_i} = -\frac{\Pi_{j\theta}}{\Pi_{i\theta}}$. This implies $\frac{\partial^2 \tilde{W}_j}{\partial k_j^2} < 0$, since $\frac{\partial^2 \tilde{W}_j}{\partial k_j^2} = \Pi_{12}\frac{\partial \hat{K}_i}{\partial k_j} + \Pi_{jj} = -a\frac{\partial \hat{K}_i}{\partial k_j} - (q_j + a) = -a(\frac{\partial \hat{K}_i}{\partial k_j} + \frac{m_j}{m_i}Q_j) < 0$. Thus $\frac{\partial \tilde{W}_j}{\partial k_j}$ is decreasing over those intervals where it is continuous, but note that it has discontinuities at $k_j = \underline{k}_j(\theta)$ and at $k_j = \bar{k}_j(\theta)$, since $\frac{\partial \hat{K}_i}{\partial k_j}$ is discontinuous at those points.

Consider first $k_j < \underline{k}_j(\theta)$. We have then (explanations to follow)

$$\begin{aligned}\frac{\partial \tilde{W}_j}{\partial k_j}(k_j, \theta, \check{\theta}_j) &> \frac{\partial \tilde{W}_j}{\partial k_j}(\underline{k}_j(\theta)^-, \theta, \check{\theta}_j) \geq \frac{\partial \tilde{W}_j}{\partial k_j}(\underline{k}_j(\bar{\theta})^-, \bar{\theta}, \check{\theta}_j) \\ &= \frac{\partial \Pi}{\partial K_j}(\bar{K}_i, \bar{K}_j, \bar{\theta}) - \gamma_j(\Pi_{i\theta}\frac{-a}{q_i + a} + \Pi_{j\theta})(\check{\theta}_j - \bar{\theta}) \\ &= \gamma_j \Pi_{i\theta}(\frac{aK_i'}{aK_j' - m_i} - \frac{-a}{q_i + a})(\check{\theta}_j - \bar{\theta}) \geq 0\end{aligned}$$

where $\underline{k}_j(\theta)^-$ indicates a limit from below. The last equality follows from the equilibrium condition (ref: DEQ / ref: DE1), and the last inequality from $\frac{aK_i'}{aK_j' - m_i} - \frac{-a}{q_i + a} = \frac{a}{q_i + a}\frac{1}{m_i - aK_j'}[m_i - aK_j' - (q_i + a)K_i'] < 0$ by (ref: imp , ref: E1). The first inequality above follows from $\frac{\partial^2 \tilde{W}_j}{\partial k_j^2} < 0$, and the second from the expression being decreasing in θ: we have $\frac{\partial \tilde{W}_j}{\partial k_j}(\underline{k}_j(\theta)^-, \theta, \check{\theta}_j) = \frac{\partial \Pi}{\partial K_j}(\bar{K}_i, \underline{k}_j(\theta), \theta) - \gamma_j(\Pi_{i\theta}\frac{-a}{q_i + a} + \Pi_{j\theta})(\check{\theta}_j - \theta)$, and hence $\frac{d}{d\theta}\frac{\partial \tilde{W}_j}{\partial k_j}(\underline{k}_j(\theta)^-, \theta, \check{\theta}_j) = \Pi_{jj}\underline{k}_j' + \Pi_{j\theta} + \gamma_j(\Pi_{i\theta}\frac{-a}{q_i + a} + \Pi_{j\theta})$. Substituting for $\underline{k}_j' = \frac{\Pi_{i\theta}}{-\Pi_{12}} = \frac{m_i}{a}$, the last expression can be written as $-\frac{m_j}{Q_i}[Q_i(Q_j - 1) - \gamma_j(Q_i - 1)] \leq 0$ from the assumption stated in the proposition. This establishes that $\frac{\partial \tilde{W}_j}{\partial k_j} \geq 0$ for $k_j < \underline{k}_j(\theta)$.

Consider next $k_j > \bar{k}_j(\theta)$. We have then, by parallell arguments;

$$\begin{aligned}\frac{\partial \tilde{W}_j}{\partial k_j}(k_j, \theta, \check{\theta}_j) &< \frac{\partial \tilde{W}_j}{\partial k_j}(\bar{k}_j(\theta)^+, \theta, \check{\theta}_j) \leq \frac{\partial \tilde{W}_j}{\partial k_j}(\bar{k}_j(\underline{\theta})^+, \underline{\theta}, \check{\theta}_j) \\ &= \frac{\partial \Pi}{\partial K_j}(\underline{K}_i, \underline{K}_j, \underline{\theta}) - \gamma_j(\Pi_{i\theta}\frac{-a}{q_i + a} + \Pi_{j\theta})(\check{\theta}_j - \underline{\theta}) \leq 0.\end{aligned}$$

Consider finally $k_j \in [\underline{k}_j(\theta), \bar{k}_j(\theta)]$. Since $\tilde{W}_j(k_j, \theta, \check{\theta}_j)$ is strictly concave in k_j on this interval, and the first-order condition is satisfied for $K_j(\theta) \in [\underline{k}_j(\theta), \bar{k}_j(\theta)]$, this investment level does then maximize the function.

Finally, since we have shown that the tax schedule $R_j(K_j)$ implements $K_j(\theta)$ when country i offers the schedule $R_i(K_i)$, it follows that $R_j(K_j)$ is a best response to $R_i(K_i)$. This completes the proof.

Proof of Proposition 9

Total welfare is $W_1 + W_2 = (1 + \lambda)\Sigma r_j(\theta) + \Sigma \alpha_j \pi(\theta)$. Since rents $\pi(\theta)$ are constant across the relevant equilibria, total welfare will vary in the same manner as total revenue varies. Incentive compatibility implies $r_j'(\theta) = \frac{\partial \Pi}{\partial K_j}K_j'(\theta)$. From the equilibrium conditions (ref: DEQ , ref: DE1) we have $\frac{\partial \Pi}{\partial K_j} = \Gamma_j m_j(\check{\theta}_j - \theta)$, where $\Gamma_j \equiv \frac{1 + \lambda - \alpha_j}{1 + \lambda}\left[1 + \frac{\frac{a}{m_j}K_i'}{\frac{a}{m_i}K_j' - 1}\right]$. Then using (ref: E2) to substitute for $\Gamma_j m_j \check{\theta}_j$, we obtain

$$r_1'(\theta) + r_2'(\theta) = \sum_j (k - (q_j + a)L_j - aL_i)K_j' - \theta\sum_j \Gamma_j m_j K_j'.$$

We may write

$$\sum_j(-(q_j+a)L_j - aL_i)K_j' = (-(q_1+a)L_1 - aL_2)K_1' + (-(q_2+a)L_2 - aL_1)K_2'$$
$$= L_1(-(q_1+a)K_1' - aK_2') + L_2(-(q_2+a)K_2' - aK_1') = \sum_j L_j(-m_j - \Gamma_j m_j),$$
where the last equality follows from (ref: E1). Hence we have
$$r_1'(\theta) + r_2'(\theta) = \sum kK_j' - \sum m_j L_j - \sum \Gamma_j m_j L_j - \theta \sum \Gamma_j m_j K_j'.$$
All terms except $\sum \Gamma_j m_j L_j$ are uniquely determined. Integrating twice we may write the expected revenue as
$$E(r_1(\theta) + r_2(\theta)) = C_1 - \tfrac{1}{2}\sum \Gamma_j m_j L_j + r_1(\underline{\theta}) + r_2(\underline{\theta}),$$
where C_1 is uniquely determined. Since $K_j(\underline{\theta}) = L_j$ we have $r_1(\underline{\theta}) + r_2(\underline{\theta}) = \Pi(L_1, L_2, \underline{\theta}) - n(\underline{\theta})$. By substitution, and by collecting terms that are uniquely determined, we can then write
$$E(r_1(\theta) + r_2(\theta)) = C_3 - \tfrac{1}{2}\sum \Gamma_j m_j L_j + k\sum L_j - \tfrac{1}{2}\sum q_j L_j^2 - \tfrac{1}{2}a(L_1 + L_2)^2$$
This is to be maximized, subject to $\sum m_j L_j = M$ (a constant). The first-order conditions are $-\frac{1}{2}\Gamma_j m_j + k - q_j L_j - a(L_1 + L_2) = \mu m_j$, where μ is a Lagrangian multiplier. This yields
$$-\tfrac{1}{2}\Gamma_1 + \tfrac{k}{m_1} - \tfrac{a}{m_2}Q_1 L_1 - \tfrac{a}{m_1}L_2 = -\tfrac{1}{2}\Gamma_2 + \tfrac{k}{m_2} - \tfrac{a}{m_1}Q_2 L_2 - \tfrac{a}{m_2}L_1,$$
where $Q_j = \frac{m_i}{m_j}(\frac{q_j}{a} + 1)$. From equations (ref: E1) we see that we may write $1 - Q_j\frac{a}{m_i}K_j' - \frac{a}{m_j}K_i' = -\Gamma_j$. Substituting for Γ_j in the equation above yields the formula given in the proposition.

When the countries have symmetric technologies, we have $Q_1 = Q_2,\ m_1 = m_2$ and hence $L_1 + \frac{1}{2}K_1' = L_2 + \frac{1}{2}K_2'$. Equal owner shares yields $K_1' = K_2'$, while $K_1' < K_2'$ when $\alpha_1 > \alpha_2$, see Proposition 6. This completes the proof.

Proof of Proposition 10.

In the fully symmetric case one can easily solve for and compare the slope parameters of the investment schedules for the cooperative and the competitive regime, respectively. One finds that (see Olsen and Osmundsen 1998 for details)
$$K_{jC}' \lesseqgtr K_j' \qquad \text{iff} \qquad \frac{1+\lambda}{\alpha_1+\alpha_2} \lesseqgtr \Psi^{-1} = \frac{q}{4a} + 1.$$
Consider the case $\frac{1+\lambda}{\alpha_1+\alpha_2} < \Psi^{-1}$. The investment schedule is then steeper in the competitive regime ($K_{jC}' < K_j'$). If the outside value function is type-independent (the conventional case), then for both regimes the IR constraints are binding only for the low type $\underline{\theta}$, and there is 'no distortion at the top' ($\check{\theta} = \check{\theta}_j = \bar{\theta}$ in our notation). Hence we have $K_{jC}(\theta) > K_j(\theta)$ for all types but type $\bar{\theta}$. (The cooperative schedule is flatter, and investment levels are equal for $\theta = \bar{\theta}$.) It follows that investments are lower under competition, and hence that rents are lower in that regime too (Olsen and Osmundsen 1998). Let $\bar{\pi}_C$ and $\bar{\pi}$ denote the rents accruing to type $\bar{\theta}$ in this case, under cooperation and competition, respectively. We have $\bar{\pi} < \bar{\pi}_C$. The least efficient type obtains rents $n(\underline{\theta})$ in both regimes. In the following we fix $n(\underline{\theta})$ and consider various forms that $n(\theta)$ may take for $\theta > \underline{\theta}$.

The IR constraints will continue to bind only for the least efficient type in both regimes as long as the outside value $n(\theta)$ is sufficiently convex and $n(\bar{\theta}) < \bar{\pi}$. Investments and rents are then in both regimes the same as when the outside value is type-independent. This covers case (iii) in the proposition.

Consider next $\bar{\pi} < n(\bar{\theta}) < \bar{\pi}_C$. Assuming $n(\theta)$ is sufficiently convex, the IR constraints for the cooperative case will not be affected, while those for the competitive case will be affected in such a way that the IR constraint now becomes binding for type $\bar{\theta}$ in addition to type $\underline{\theta}$. In the competitive symmetric equilibrium we then have $\check{\theta}_j < \bar{\theta}$ and thus overinvestments compared to the first-best for $\theta > \check{\theta}_j$. Since cooperative investments are the same as in the conventional case considered above (IR constraints binding only for the low-efficiency type), and thus exhibit underinvestment relative to the first-best, they must also exhibit underinvestment relative to competitive investments ($K_{jC}(\theta) < K_j(\theta)$) for $\theta > \tilde{\theta}$, for some $\tilde{\theta} < \check{\theta}_j$. We cannot have underinvestment for all types, since that would imply uniformly lower rents in the cooperative regime, and we have assumed $\pi(\bar{\theta}) = n(\bar{\theta}) < \pi_C(\bar{\theta})$. Hence we have $K_{jC}(\theta) > K_j(\theta)$ for low-efficiency types ($\theta < \tilde{\theta}$). This covers case (ii) in the proposition as far as investments are concerned.

To see that rents are for (almost) all types higher in the cooperative regime in this case, note that we have $\pi_C(\underline{\theta}) = \pi(\underline{\theta})$, $\pi'_C(\theta) > \pi'(\theta)$ for $\theta < \tilde{\theta}$, and $\pi_C(\bar{\theta}) > \pi(\bar{\theta})$. Since both functions are quadratic (and therefore cannot cross more than twice), it follows that $\pi_C(\theta) > \pi(\theta)$ for all $\theta > \underline{\theta}$. This proves the statements regarding case (ii).

Finally consider an outside value $n(\theta)$ where $n(\bar{\theta}) > \bar{\pi}_C > \bar{\pi}$. Again, given that $n(\theta)$ is sufficiently convex, the IR constraints will be binding for types $\bar{\theta}$ and $\underline{\theta}$ under both regimes, so we have $\pi_C(\theta) = \pi(\theta) = n(\theta)$ for $\theta = \underline{\theta}, \bar{\theta}$. It follows that the investment schedules $K_{jC}(\theta)$ and $K_j(\theta)$ must cross (once). Otherwise the highest schedule would generate higher rents for all types $\theta > \underline{\theta}$, and this would violate $\pi_C(\bar{\theta}) = \pi(\bar{\theta})$. Since $K_j(\theta)$ is steepest, it must be below $K_{jC}(\theta)$ for low-efficiency types, and this implies $\pi'_C(\theta) > \pi'(\theta)$ for these types. This in turn yields $\pi_C(\theta) > \pi(\theta)$ for all θ in $(\underline{\theta}, \bar{\theta})$. The statements regarding case (i) are thereby proved.

This completes the proof for the parameter configuration $\frac{1+\lambda}{\alpha_1+\alpha_2} < \Psi^{-1}$. The complementary case can be handled similarly. QED.

Proof of Proposition 11.

Since the countries are symmetric with respect to technologies and owner shares, equations (ref: E1) admit unique solutions K'_j, with $K'_1 = K'_2$. For every η in (η_1, η_2), and every outside value function in the familiy $N(\eta)$, there is a unique symmetric equilibrium of the form given in Corollary 5, with parameters $L_1 = L_2$ and $\check{\theta}_1 = \check{\theta}_2 \in (\underline{\theta}, \bar{\theta})$. From (ref: E2 , ref: F1) we see that these parameters are in fact linear functions of η; with $L_j(\eta)$ strictly increasing and $\check{\theta}_j(\eta)$ stricly decreasing.

The total value $E(W_1 + W_2)$ associated with this equilibrium can be written as

$$(1+\lambda)\int_{\underline{\theta}}^{\bar{\theta}} \left\{ \Pi(K_1, K_2, \theta) - (1 - \frac{\alpha_1+\alpha_2}{1+\lambda}) \frac{\partial \Pi}{\partial \theta}(K_1, K_2, \theta) \frac{F(\check{\theta}_1) - F(\theta)}{f(\theta)} \right\} dF(\theta)$$
$$- (1 + \lambda - \alpha_1 - \alpha_2)\left\{ \pi(\underline{\theta})F(\check{\theta}_1) + \pi(\bar{\theta})[1 - F(\check{\theta}_1)] \right\},$$

where $K_j = K_j(\theta; \eta) = L_j(\eta) + K'_j\theta$, $\check{\theta}_1 = \check{\theta}_1(\eta)$, $\pi(\underline{\theta}) = 0$ (by our normalization) and $\pi(\bar{\theta}) = \eta$. Note that the derivative of this expression wrt. $\check{\theta}_1$ is zero. Using the uniform distribution, the marginal effect on total expected welfare ($\frac{\partial}{\partial \eta}E(W_1 + W_2)$) can then be written as $(1+\lambda)$ times the following expression

$$\int_{\underline{\theta}}^{\bar{\theta}} \sum_j \left\{ \frac{\partial \Pi}{\partial K_j} - (1 - \frac{\alpha_1+\alpha_2}{1+\lambda}) \frac{\partial^2 \Pi}{\partial K_j \partial \theta}(\check{\theta}_1 - \theta) \right\} \frac{\partial K_j}{\partial \eta} d\theta - (1 - \frac{\alpha_1+\alpha_2}{1+\lambda})[1 - \check{\theta}_1].$$

Using (ref: DEQ , ref: DE1) and symmetry we can write this as

$$\left[2(1 - \frac{\alpha_1}{1+\lambda})[m + \frac{maK'_1}{aK'_1 - m}] - (1 - \frac{2\alpha_1}{1+\lambda})2m \right] \int_{\underline{\theta}}^{\bar{\theta}} (\check{\theta}_1 - \theta) d\theta \frac{\partial K_1}{\partial \eta} - (1 - \frac{2\alpha_1}{1+\lambda})[1 - \check{\theta}_1]$$

Note that $\eta = \eta_1$ yields $\check{\theta}_1 = \bar{\theta} = 1$, and hence

$$sign \frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1} = sign \left[(1 - \frac{\alpha_1}{1+\lambda})[1 + \frac{aK'_1}{aK'_1 - m}] - (1 - \frac{2\alpha_1}{1+\lambda}) \right]$$

From (ref: F1) we see that $\frac{\partial K_1}{\partial \eta} = \frac{\partial L_1}{\partial \eta} = \frac{1}{2m}$. Differentiating once more we obtain

$$\frac{\partial^2}{\partial \eta^2} \frac{E(W_1 + W_2)}{(1+\lambda)} = \left\{ \left[(1 - \frac{\alpha_1}{1+\lambda})[1 + \frac{aK'_1}{aK'_1 - m}] - (1 - \frac{2\alpha_1}{1+\lambda}) \right] + (1 - \frac{2\alpha_1}{1+\lambda}) \right\} \frac{\partial \check{\theta}_1}{\partial \eta} < 0$$

where the inequality follows from (ref: imp) and $\frac{\partial \check{\theta}_1}{\partial \eta} < 0$. Hence the total value $E(W_1 + W_2)$ is srictly concave in η, and therefore increasing for some η if and only if $\frac{\partial}{\partial \eta}E(W_1 + W_2) > 0$ for

$\eta = \eta_1$. Using $\gamma = 1 - \frac{\alpha_1}{1+\lambda}$, we have

$$\frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1} > 0 \qquad \text{iff} \qquad \gamma[1 + \frac{aK_1'}{aK_1' - m}] - (1 - 2(1-\gamma)) \; > 0.$$

Using (ref: E1), the condition is equivalent to $-1 + (\frac{q}{a} + 2)\frac{a}{m}K_1' + 1 - 2\gamma > 0$. Since (ref: E1) can be solved explicitly for K_1' in this case, we find that the condition is equivalent to $1 + \gamma + \frac{Q}{2} - \sqrt{\gamma + \gamma^2 + \frac{Q^2}{4}} - 2\gamma > 0$, where $Q = \frac{q}{a} + 1$. This holds iff $1 - 2\gamma + \gamma^2 + (1-\gamma)Q + \frac{Q^2}{4} > \gamma + \gamma^2 + \frac{Q^2}{4}$, i.e. iff $1 + Q > \gamma(Q+3)$. Substituting for $\gamma = 1 - \frac{\alpha_1}{1+\lambda}$ and $Q = \frac{q}{a} + 1$, we see that the latter condition is equivalent to $\frac{\alpha_1}{1+\lambda} > \frac{2}{4+q/a}$.

Finally note that for $\eta = \eta_2$ we have (by definition of η_2) $\check{\theta}_j = \underline{\theta} = 0$, and hence

$$\frac{\partial}{\partial \eta}\left[\frac{E(W_1 + W_2)}{(1+\lambda)}\right]_{\eta=\eta_2} = [(1 - \frac{\alpha_1}{1+\lambda})[1 + \frac{aK_1'}{aK_1' - m}] - (1 - \frac{2\alpha_1}{1+\lambda})](-\frac{1}{2}) - (1 - \frac{2\alpha_1}{1+\lambda}) < 0$$

This completes the proof.

References

Baron, D.P., and D. Besanko, 1984, Regulation and Information in a Continuing Relationship, Information Economics and Policy 1, 267-302.

Biglaiser, G., and C. Mezzetti, 1993, Principals Competing for an Agent in the Presence of Adverse Selection and Moral Hazard, Journal of Economic Theory 61, 302-330.

Bond, E.W., and T.A. Gresik, 1996, Regulation of Multinational Firms with Two Active Governments: A Common Agency Approach, Journal of Public Economics 59, 33-53.

Calzolari, G., 1998, Regulation in an International Setting, the Case of a Multinational Enterprise, mimeo, GREMAQ, Université des Sciences Sociales de Toulouse.

Dasgupta, P., P. Hammond, and E. Maskin,1979, The Implementation of Social Choice Rules, Review of Economic Studies 46, 185-216.

Devereux, M.P., and H. Freeman, 1995, The Impact of Tax on Foreign Direct Investment: Empirical Evidence and the Implications for Tax Integration Schemes, International Tax and Public Finance 2, 85-106.

Favardin, P. and A. Soubeyran, 1995, Firm Attraction by a Local Jurisdiction: a Principal-Agent Approach, Working Paper 33/95, GREQAM, Marseille.

Gresik, T. A., 1998, The Taxing Task of Taxing Transnationals, Keynote speech for the Petropol Research Conference on National Resource Management, Internationalisation and Strategic Behaviour, Bergen, Norway, 22-23 October 1998.

Guesnerie, R. and J.J. Laffont, 1984, A Complete Solution to a Class of Principal-Agent Problems with an Application to the Control of a Self-Managed Firm, Journal of Public Economics 25, 329-369.

Jullien, B., 1996, Participation Constraints in Adverse Selection Models, mimeo, CNRS-GREMAQ.

Laffont, J.-J., and J. Tirole, 1986, Using Cost observation to Regulate Firms, Journal of Political Economy 94, 614-641.

Laffont, J.-J., and J. Tirole, 1988, Repeated Auctions of Incentive Contracts, Investment and Bidding Parity, with an Application to Takeovers, Rand Journal of Economics 19, 516-537.

Laffont, J.-J., and J. Tirole, 1993, A Theory of Incentives in Procurement and Regulation, MIT-Press, Cambridge, Massachusetts.

Laussel, D., and M. Lebreton, 1995, On the Tax Schedule Nash Equilibria of a Fiscal Competition Game II: The Large Investor’s Case, unpublished note, LEQUAM, University of Aix-Marseilles 2.

Lewis, T. and D. Sappington, 1989, Countervailing Incentives in Agency Problems, Journal of Economic Theory 49 (2), 294-313.

Maggi, G. and A. Rodríguez-Clare, 1995, On Countervailing Incentives, Journal of Economic Theory 66, 238-263.

Markusen, J.R., 1995, The Boundaries of Multinational Enterprises and the Theory of International Trade, Journal of Economic Perspectives 9(2), 169-189.

Martimort, D., 1992, Multi-Principaux avec Anti-Selection, Annales D’Économie et de Statistique 28, 1-37.

Martimort, D. and L. Stole, 1997, Communication Spaces, Equilibria Sets, and the Revelation principle under Common Agency, Discussion paper #STE029, GSB, The University of Chicago.

Mezzetti, C., 1997, Common Agency with Horizontally Differentiated Principals, Rand Journal of Economics 28, 325-345.

Olsen, T.E., 1993, Regulation of Multiagent Research and Development,
Rand Journal of Economics 24, 529-541.

Olsen, T. E., 1999, On the revelation principle in common agency. Mimeo.

Olsen, T. E. and P. Osmundsen, 1998, Strategic Tax Competition: Implications of National Ownership, Working Paper no. 1098, Department of Economics, University of Bergen.

Osmundsen, P., 1997, Corporate Taxation under Endogenous Mobility, Discussion Paper 6/98, Department of Economics, Norwegian School of Economics and Business Administration.

Osmundsen, P., 1999, Taxing Internationally Mobile Individuals- A Case of Countervailing Incentives, forthcoming in International Tax and Public Finance.

Osmundsen, P., Hagen, K.P., and G. Schjelderup, 1998, Internationally Mobile Firms and Tax Policy, Journal of International Economics 45, 97-113.

Rochet, J.-C. and P. Chone, 1998, Ironing, sweeping, and Multidimensional Screening, Econometrica 66(4), 783-826.

Stole, L., 1992, Mechanism Design under Common Agency, Working paper, University of Chicago.

Wildasin, D., 1988, Nash Equilibria in Models of Fiscal Competition, Journal of Public Economics 35, 229-240.

Zodrow, G.R. and P. Mieszkowski, 1986, Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods, Journal of Urban Economics 19, 356-370.

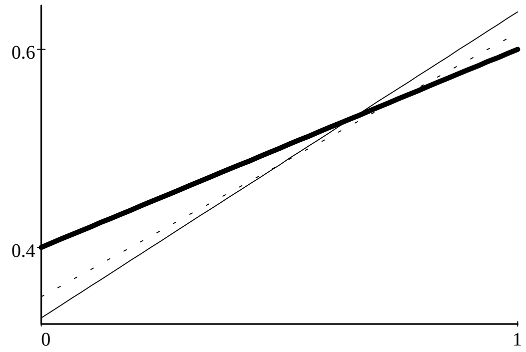

Figure 1. First-best (heavy line), cooperative (