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## Conference Paper

# Lobbying and the Power of Multinational Firms

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Lobbying and Elections, No. D03-V2

### Provided in Cooperation with:

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Polk, Andreas; Schmutzler, Armin; Müller, Adrian (2013) : Lobbying and the Power of Multinational Firms, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Lobbying and Elections, No. D03-V2, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

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# Lobbying and the Power of Multinational Firms

Andreas Polk, Armin Schmutzler and Adrian Muller\*

August 19, 2013

**Abstract:** Can multinational firms exert more power than national firms by influencing politics through lobbying? To answer this question, we analyze the extent of national environmental regulation when policy is determined in a lobbying game between a government and a firm. We compare the resulting equilibrium regulation levels, outputs and welfare in a game with a multinational firm with those in an otherwise identical game with a national firm. For low transportation costs, output and pollution of a national firm is always as least as high as for a multinational; this changes for high transportation costs and intermediate damage parameters. When there is no lobbying, welfare levels are always higher with multinationals than with national firms. However, the existence of lobbying may reverse this ordering.

**Keywords:** Multinational enterprises, regulation, pollution, policy formation, lobbying, interest groups, foreign direct investment.

**JEL:** D72, F23, L51.

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# 1 Introduction

Even though global foreign direct investment has faced two major negative shocks since the turn of the century, the stock of foreign capital in most countries is much higher than several decades ago. Some authors argue that the lobbying influence on the political process has grown due to this aspect of globalization. This perception sometimes culminates in the notion of the 'loss of sovereignty' of the nation state. According to this view, national governments lose their discretion to set policy, e.g. environmental regulation, because multinational enterprises have a better lobbying position vis-à-vis governments than national firms: the former can relocate in response to unwanted policies, and governments that want to avoid such relocation must succumb to the wishes of the multinationals. In this fashion, a race to the bottom ensues when multinational firms are important, leading to 'pollution havens' with excessively lax regulation to attract multinational firms. Contrasting this view is the 'Not in my backyard' (NIMBY) story: If pollution causes high damages, governments may set inefficiently high pollution standards to deter polluting multinationals.

Such motivated, we ask whether the growing importance of multinational firms indeed leads to harmful policy biases and, in particular, whether it leads to lax pollution regulation. We focus on the perspective of a small country that has to take environmental regulation in the rest of the world as given. This framework applies to the interaction of industrialized countries with transition economies and LDCs, or to cases where some industrialized countries decides to introduce stricter environmental regulation than others due to national preferences.<sup>1</sup>

We analyze how such countries set their regulation when they face a footloose ("multinational") monopolist that can choose where to set up its production facilities. The monopolist can engage in lobbying activities to influence regulation. To bring out the role of a footloose firm's ability to freely choose locations, we compare the outcome with the one that would emerge with a "national" monopolist that is restricted to produce in its home country.

More specifically, we consider a stylized three-stage game related to Motta and Thisse (1994) and Markusen et al. (1993, 1995). In period 1, the small-

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<sup>1</sup>For instance, in contrast to European countries and Australia, the United States never ratified the Kyoto Protocol and Canada recently withdrew from it for fears of unemployment and negative economic effects. Also, countries follow divergent national regulatory approaches towards the use of nuclear energy. Regulation in France is rather lax and allows for exports to third countries, whereas Germany's approach has traditionally been stricter, culminating in the recent decision to phase out nuclear energy production.

country regulator chooses the level of a pollution standard that raises unit costs. In period 2, the monopolist chooses whether to open a plant in the foreign country as well (“partial relocation”) or even close down production in the small country altogether (“complete relocation”). In period 3, the monopolist chooses quantities on the two markets. International trade is allowed, but subject to trade or transportation costs. The exogenous parameters capture demand, environmental damages, transportation costs and fixed costs of production. Our modeling approach allows both for the case that regulators maximize welfare and the alternative that they take private benefits into account, which makes them susceptible to lobbying.

We determine all equilibria of the game and the associated welfare levels. We show how increased lobbying activities of a multinational monopolist affect regulation and location patterns. We compare the outcome of the lobbying game with a multinational monopolist to the outcome in an otherwise analogous game where the monopolist is a purely national firm (it can export, but it lacks the option to relocate). We are thus able to determine whether a multinational or a national firm is a more effective lobbyist and demonstrate that both cases may result.

As a benchmark case, we first study a situation where the regulator applies a consumer standard, that is, cares only about consumer surplus and environmental damage. Whether the national or multinational firm produces and pollutes more will depend on transportation costs and the environmental damage parameter: For low transportation costs, the national firm never produces less than the multinational firm, and it produces more for non-degenerate parameter constellations. This reflects the intuition that the regulator will usually be willing to accept small losses in consumer surplus resulting from relocation of the multinational firm in exchange for potentially large environmental gains. For high transportation costs, the picture is reversed when environmental damages are at intermediate levels, in which case the multinational firm will produce and pollute more in the small country than the national firm. Essentially, imposing strict regulation has greater benefits with a national firm than with a multinational firm. For high transportation costs, the multinational firm does not export to the foreign country, so that regulation only affects pollution resulting from production for the home country. For the national firm, however, regulation also curbs pollution resulting from exports to the foreign country.

With lobbying (captured by a positive weight of producer surplus in the regulator’s objective function), these equilibrium patterns remain qualitatively similar. However, because regulation is reduced both for national and for multinational firms, the regions where relocation or shut-down of production is induced become smaller, and they require higher values of the

equilibrium damage parameters.

A striking consequence of our analysis is that, for more dangerous pollutants, welfare can be lower with a multinational firm than with a national firm when lobbying is sufficiently strong. This arises even though our setting is biased towards multinational firms in the sense that, when there is no lobbying welfare is always higher with a multinational monopolist than with a purely national monopolist.

In the main text, we analyze a model with specific functional forms for demand, costs, environmental damage and the type of regulation and identify all relevant effects. In the appendix, we then consider a reduced form approach which generalizes the most important insights of the specific model. It turns out that neither the specific functional forms nor the assumption of monopoly markets are necessary for the main results.

After a brief discussion of related literature in Section 2, Section 3 describes the model. Section 4 derives the locational choices of firms for given regulation levels. In Section 5, we characterize regulation for national and multinational firms, respectively. Section 6 compares regulation levels in the two cases, and it shows how lobbying affects the comparison. Section 7 deals with welfare issues. Section 8 concludes.

## 2 Related literature

Our model relates to several strands of literature. First, there are theoretical and empirical contributions which analyze whether the ability of multinationals to relocate production leads to pollution havens which have low regulation in order to attract foreign capital (i.e. Rauscher, 1995). Even though early empirical research found it hard to confirm this effect, recent contributions provide evidence that regulation does indeed have an impact on the location decisions of firms (Brunnermeier and Levinson, 2004; Levinson and Taylor, 2008).

Second, from a theoretical perspective, lobbying of multinational firms has mostly been analyzed in the context of endogenous trade policy, under the assumption that the location choices of firms are exogenous. The literature focuses on the ability of multinational firms to circumvent trade barriers through relocation that provides them with a weight in the political game.<sup>2</sup>

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<sup>2</sup>Grossman and Helpman (1996) analyze domestic lobbying for protection if FDI serves as a threat to circumvent trade barriers. Stoyanov (2009), Gawande et al. (2006), Konishi et al. (1999) analyze lobbying of foreign firms against trade protection. Aidt and Alborno (2011) analyze lobbying efforts of multinationals directed at protecting investments against taxes or other expropriation measures abroad.

Third, some contributions address lobbying in the context of plant relocation when regions compete for or against the settlement of firms which produce a local public good or bad. For instance, Bellettini and Kempf (2008) analyze the spatial allocation of production plants when regions lobby a central government to influence the local presence of a firm. Lobbying may lead to over- or underprovision of the public good which the firms provide. Closely related, Fredriksson (2000) analyzes the allocation of a plant which exerts negative externalities in a NIMBY setting where each region lobbies against the location of the plant at its own site but benefits from its existence somewhere else. Even though both papers also deal with how lobbying influences location patterns, our model focuses on lobbying of firms, rather than lobbying of regions.

Fourth, like the present paper Cole et al. (2006) analyze lobbying activities of multinational and national firms against environmental regulation when local production causes pollution damages. The contribution analyzes how an increase in the number of foreign plants affects environmental regulation in the presence of lobbying. In contrast to our approach, the market structure is exogenous and relocation is not allowed.

Fifth, empirical studies indicate that foreign and multinational firms influence the political process. Even though the extent of lobbying tends to be smaller for multinational than for domestic firms, the former have a significant effect on domestic politics (Gawande et al., 2006; Hansen and Mitchell, 2000).<sup>3</sup>

### 3 Assumptions

We consider a multi-stage game of environmental regulation in a small country: Its environmental regulation does not induce reactions of policy in the rest of the world, which has a low level of regulation that we normalize to zero.

#### 3.1 Product market

There are two countries,  $i = 1$  (home) and  $i = 2$  (foreign). There is one firm that initially only has one plant in the home country. This firm can be

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<sup>3</sup>More broadly related, in a contribution with an empirical focus, Fredriksson et al. (2003) assess how lobbying and corruption of state employees affect environmental regulation and inbound FDI into the United States. In their model, the allocation of capital is endogenous; workers and environmental groups lobby for environmental regulation whereas capital owners do not.

national or multinational. A multinational firm is defined by the option to build another plant in the foreign country.<sup>4</sup> Even for the multinational firm, we will assume that at least a positive fraction of its owners live in the country under consideration.

We assume that a politician in country 1 maximizes a “welfare function” ( $W$ ), a weighted sum of consumer surplus in the home country ( $K$ ), total firm profits ( $\Pi$ ), net of the costs of environmental damage in the home country ( $D$ ):

$$W = K + \gamma\Pi - D,$$

where  $\gamma \geq 0$ . The game has the following stages:

1. The politician chooses the regulation level  $r$  so as to maximize  $W$ .
2. If the firm is multinational, it decides whether to build an additional plant in the foreign location at fixed cost  $F$ ; a national firm is defined by the absence of this option.<sup>5</sup>
3. The profit-maximizing firm chooses  $x_j^i$ ,  $i, j = 1, 2$ , which denotes the output levels produced in country  $i$  for country  $j$ .

We write  $x^i = (x_1^i + x_2^i)$  for total output produced in country  $i$ , and  $x_j = (x_j^1 + x_j^2)$  for total output produced for consumption in country  $j$ . Further, we write  $x = (x_1^1, x_2^1, x_1^2, x_2^2)$ . *Partial relocation* (P) occurs if  $x^1 > 0$  and  $x^2 > 0$ , that is, production takes place in both countries. There is *complete relocation* (C) if  $x^1 = 0$ ,  $x^2 > 0$ , that is, all production takes place in country 2. If  $x^2 = 0$ , we say that there is *no relocation* (N).

We assume that the firm is a monopolist on both markets who faces linear demand  $p_i = \max\{a - x_i, 0\}$  in country  $i = 1, 2$ . We assume constant marginal production costs, which we set to 0 for simplicity. If a market is served from another country, the firm incurs transportation (or trade) costs  $t > 0$  per unit output. Regulation is assumed to increase the costs of production, and additional costs  $r$  are proportional to output. Profits are thus

$$\sum_{j=1}^2 p_j(x_j)x_j - rx^1 - t(x_2^1 + x_1^2) - \delta F \quad (1)$$

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<sup>4</sup>Our main insights still hold if both firms can relocate in principle, but a “multinational” firm can do so at lower costs than a “national” firm, reflecting a home bias of the latter.

<sup>5</sup>Fixed costs are sunk and cannot be recurred by shutting down a plant location. They are independent of the type of relocation (partial or complete). Allowing for differences in the fixed costs of partial and complete relocation does not change the main insights of the analysis and adds more notation.

where  $\delta = 1$  if there is complete or partial relocation,  $\delta = 0$  otherwise, that is, for a national firm or a multinational firm that does not relocate. Environmental damages are given as  $b(x^1)^2$ , where  $b > 0$ . In the foreign country, there is no regulation. Again, we can think of this as a convenient normalization, except that we are restricting the country under consideration to introduce regulation that goes beyond the level in other countries.<sup>6</sup> The model thus has the exogenous parameters  $a, F, b, t, \gamma$ . The regulation level  $r$  is endogenous, as is the location choice and more generally the output vector  $x$ .

### 3.2 Lobbying interpretation

The welfare function can account for the cases that the politician is either benevolent or influenced by lobbying of firms. In the former case,  $\gamma$  reflects the weight that the benevolent politician gives to producer surplus.<sup>7</sup> In the latter case, which is our preferred interpretation, a standard lobbying game (similar to Grossman and Helpman, 1994) fits into our simpler framework. To this end, we add a first stage in which the firm offers a contribution schedule  $C(r)$  to the politician, which maps a particular level of regulation to a contribution that the firm pays to the politician. The firm's objective function thus becomes  $\pi(r) = \Pi(r) - C(r)$ , that is, profits minus contributions. Next the politician sets regulation levels so as to maximize  $U(r) = \widehat{W}(r) + \beta C(r)$ , where  $\beta \geq 0$  and  $\widehat{W}(r) = K + \widehat{\gamma}\Pi - D$  is the "true" welfare function where the weight parameter  $\widehat{\gamma}$  reflects normative considerations.

In Appendix A, we show that the regulation level resulting from this more complex game maximizes a weighted sum of welfare and profits. The weight  $\gamma$  of profits is the sum of the true weight  $\widehat{\gamma}$  and the politician's concern for private benefits,  $\beta$ . Thus, our simpler game can be regarded as a reduced form of the more complex lobbying game. We also show that, if the politician cares much about welfare,  $\beta$  is small, and the firm must offer high compensation payments to induce a policy deviation of a given size.<sup>8</sup>

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<sup>6</sup>In Appendix F, we relay this assumption as well.

<sup>7</sup>Typically  $\gamma \leq 1$  would be assumed, reflecting either distributional preferences for consumers or foreign ownership of assets. Note that  $\gamma$  is independent of the location choice, which reflects the idea that the politician identifies the firm as one with national ownership independent of its production structure.

<sup>8</sup>The politician's payoff is independent of  $\beta$ . Due to the absence of lobbying competition, he is exactly compensated for the equilibrium policy deviation.



## 4 Firm behavior

We first describe the behavior of a multinational firm for given regulation; for a national firm the locational structure is fixed as  $N$  (no relocation). Intuitively, a multinational firm faces simple trade-offs when it takes location decisions. If it does not relocate, it saves fixed costs. Compared to complete relocation, it incurs the costs of regulation. Compared to partial relocation, it incurs transportation and regulation costs. If it relocates partially rather than completely, it saves transportation costs, but incurs regulation costs.

The following assumptions guarantee that (i) it is possible to earn positive profits in a country that is served from abroad and (ii) the profits that can be obtained in the unregulated foreign country from serving this country locally outweigh the fixed costs.

**Assumption 1** (i)  $t < a$ , (ii)  $a^2 > 4F$ .

In Appendix B.1, we show that, for optimal output choices, profits in the different locational regimes are:

$$\begin{aligned}\Pi^N(r) &= \begin{cases} \frac{1}{4} [2a^2 - 2a(t+2r) + (t+r)^2 + r^2] & \text{if } r \leq a-t \\ \frac{1}{4} [a^2 - 2ar + r^2] & \text{if } a-t < r \leq a \\ 0 & \text{if } a < r \end{cases} \\ \Pi^P(r) &= \frac{1}{4} [2a^2 - 2ar + r^2 - 4F] \quad \text{if } r \leq a \\ \Pi^C(r) &= \frac{1}{4} [2a^2 - 2at + t^2 - 4F] \end{aligned} \quad (2)$$

$\Pi^N(r)$ , the profit of a multinational firm that does not relocate even though it is allowed to do so in principle, is the same as the profit of a national firm that cannot relocate. The case  $r \leq a-t$  is relevant when both markets are served: The joint costs of transportation and regulation are not too high to prevent exports. If  $a-t < r \leq a$ , no profits can be earned from serving the foreign country because combined transportation costs and regulation are too high, whereas regulation is not too costly to stop production altogether. For  $a < r$  regulation alone suffices to choke production even for the home-country market.

The multinational will choose the location  $l(r) \in \{C, N, P\}$  that maximizes  $\Pi^l(r)$ . Straightforward calculations (see Appendix B.2) show that there are critical levels of regulation,  $r_1 = r_1(a, t, F)$  and  $r_2 = r_2(a, t, F)$  and  $r_3 = t$  such that location choice is given as<sup>9</sup>

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<sup>9</sup>To see this, one has to identify where  $\Pi^N = \Pi^P$ ,  $\Pi^P = \Pi^C$  and  $\Pi^N = \Pi^C$  and which location choice yields higher profits on which side of these lines of equal profits.

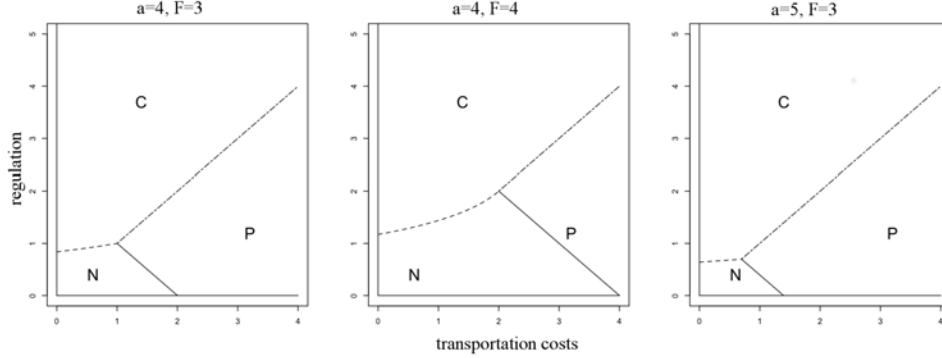


Figure 1: Location decisions of the multinational

$$l(r) = \begin{cases} N & \text{if } r \leq \min\{r_1, r_2\} \\ P & \text{if } r_1 < r < r_3 \\ C & \text{if } r \geq \max\{r_3, r_2\} \end{cases} \quad (3)$$

Figure 1 gives the location regimes for specific parameterizations. As illustrated in this figure, it is possible that  $r_1 = r_3$ , so that the partial relocation regime disappears, or that  $r_1 = 0$ , so that partial relocation arises even when there is no regulation.

Increases in  $a$  and decreases in  $F$  reduce the size of the no-relocation region.<sup>10</sup> For later purposes, we show that the relation between transportation costs and location patterns identified in Figure 1 holds more generally.

**Lemma 1:** *There exist values  $t^1 = t^1(a, F)$ ,  $t^2 = t^2(a, F)$  such that*

- (i) *For  $t \leq t^1$ , the firm chooses no relocation for low values of regulation and complete relocation for high levels. Partial relocation never arises. (NC)*
- (ii) *For  $t \geq t^2$ , the firm chooses partial relocation even for zero regulation and relocates completely for high levels of regulation (PC).*
- (iii) *For  $t^1 \leq t \leq t^2$ , the firm chooses no relocation for low values of  $r$ , partial relocation for intermediate values and complete relocation for high values. (NPC)*

The proof is straightforward (see Appendix B.3).<sup>11</sup> The intuition is simple: (i) When  $t$  is low, it is never worthwhile to build a plant in the other country to serve only this country. However, it can be worthwhile to avoid high regulation costs by relocating completely. (ii) When  $t$  is very

<sup>10</sup>This result can be derived by straightforward calculation based on the functions describing the boundaries between the three regions.

<sup>11</sup> $t^1$  corresponds to the intersection of the boundaries of all three regimes  $N$ ,  $P$  and  $C$ , and  $t^2$  corresponds to the value where the “ $\Pi^N = \Pi^P$ ”-line intersects with the  $x$ -axis.

high, the firm will always serve the other country locally even when there is no regulation. (iii) For intermediate cases all locational patterns emerge for suitable  $r$ .

## 5 Determining regulation

We first consider the optimal regulation for a national firm; then we move to the multinational firm. In Appendix C we derive the expressions for home-country welfare when the firm serves both markets ( $r \leq a - t$ ) and when it produces only for the national market ( $a - t < r \leq a$ )<sup>12</sup>. We use these expressions to characterize how the optimal regulation depends on the magnitude of the environmental damage,  $b$ , and on the firm weight,  $\gamma$ .

**Proposition 1** *For  $\gamma^1 \equiv b - \frac{1}{2} \leq \gamma^2 \equiv 2b - \frac{1}{2} \leq \gamma^3 \equiv 2b - \frac{a}{2(a-t)}$ , we have:*

- (i) *If  $\gamma \leq \gamma^1$ , regulation is so high ( $r = a$ ) that there is no production.*
- (ii) *If  $\gamma^1 < \gamma \leq \gamma^2$ , regulation is just high enough that production only occurs for the home country ( $r = a - t$ ).*
- (iii) *If  $\gamma > \gamma^2$ , there is production for both countries. If  $\gamma < \gamma^3$ ,  $r$  lies strictly between 0 and  $a - t$ , and it is decreasing in  $\gamma$  and  $t$ , increasing in  $a$  and  $b$ . If  $\gamma \geq \gamma^3$ ,  $r = 0$ .*

**Proof:** See Appendix D.

The result is intuitive: If the environmental problem is important and firms do not have much weight ( $\gamma < \gamma^1$ ), then production may be shut down completely. As the influence of firms increases ( $\gamma > \gamma^1$ ), regulation will be softened to allow production for the home country. Eventually ( $\gamma > \gamma^2$ ), regulation becomes so soft that the firm will produce for both countries, and there will be no regulation if the weight of the firm is sufficiently strong.<sup>13</sup> The critical values  $\gamma^1, \gamma^2, \gamma^3$  are increasing in  $b$ , because regulation levels depend on the trade-off between damages and concern for producer rents. For very low  $b$ , there is no regulation (even  $\gamma^3$  is negative). As the environmental problem becomes more severe ( $b$  increases), regulation increases gradually

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<sup>12</sup>This also contains the case where the firm closes down production completely ( $r = a$ ). We do not discuss the possibility that  $r > a$  explicitly, because it is equivalent to  $r = a$ . That the firm produces only for the home market if  $a - t < r$  can be seen directly from the values for the optimal output for N (equations (7) in Appendix B.1).

<sup>13</sup>The result that there never is a solution in the interior of the regime with only home country production should not be overemphasized: It comes from the fact that, in this case, because of the specific functional forms we are employing, environmental damages and consumer surplus are proportional to the square of local output.

until the firm no longer exports to the foreign country. Finally  $r$  becomes so high that production is shut down altogether.

Appendix D contains a formula for the optimal level of  $r$  when there is an interior solution in the regime where both markets are served. We will use this solution when we compare the national and multinational firm in Section 6.

We now characterize the optimal regulation of the multinational firm and the corresponding location decisions.

**Proposition 2** *There exist critical levels of firm influence  $\gamma^{C1}$ ,  $\gamma^{C2}$ ,  $\gamma^{C3}$ ,  $\gamma^{P2}$  such that:<sup>14</sup>*

(i) *For  $t \leq t^1$ , complete relocation arises if and only if  $\gamma \leq \gamma^{C1}$ , with regulation levels*

$$r^C = a - \frac{t}{2} - \frac{1}{2}\sqrt{-8F - 4at + 4a^2 + t^2};$$

*there is no relocation for  $\gamma > \gamma^{C1}$ , and the regulation level is  $r^N = 0$ .*

(ii) *For  $t^1 \leq t \leq t^2$ , there is complete relocation if and only if  $\gamma \leq \gamma^{C2}$ ; the regulation level is  $r^C = t$ . There is partial relocation if and only if  $\gamma^{C2} < \gamma \leq \gamma^{P2}$ , with regulation level*

$$r^P = a - t - \sqrt{a^2 - 4F}.$$

*There is no relocation if and only if  $\gamma > \gamma^{P2}$ ; in this case, regulation is  $r^N = 0$ .*

(iii) *For  $t > t^2$ , there is complete relocation and regulation  $r^C = t$  if and only if  $\gamma \leq \gamma^{C3}$ . There is partial relocation and  $r^P = 0$  if and only if  $\gamma^{C3} < \gamma$ .*

**Proof:** See Appendix E.

In essence, Proposition 2 states that relocation is fostered by low firm influence and low transportation costs. To prove this result, one has to take the effects of regulation on location decisions into account. Appendix C gives the welfare levels for each regime as  $W^N(r)$ ,  $W^P(r)$  and  $W^C(r)$ , respectively.  $W^N(r)$ , the welfare in regime  $N$ , is the same as for the national firm.

The regulation levels for arbitrary parameterizations of Proposition 2 will be useful when we compare the regulation of the national and multinational firm in the next section. The calculations show that a higher  $b$  works in favor of relocation, whereas increasing  $\gamma$  works against it. Furthermore, Proposition 2 shows that partial relocation only arises for sufficiently high transportation costs ( $t > t^1$ ).

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<sup>14</sup>These quantities are defined in Appendix E.

## 6 National vs. Multinational Firms

We now ask under which circumstances a multinational faces stronger regulation than a national firm. Without loss of generality, we compare the outcome of the game given  $\gamma = 0$  with the outcome for some  $\gamma > 0$ . This approach allows us to show how an increase of lobbying affects welfare and outputs for the national and the multinational firm. For the benchmark case of  $\gamma = 0$  it will turn out that welfare is always higher with a multinational rather than a national monopolist. An increase of  $\gamma$  reverses this order for non-degenerate parameter constellations.<sup>15</sup> We refer to outputs instead of the level of regulation, because outputs are in a one-to-one relation with the level of pollution.

### 6.1 Pure Consumer Surplus Maximization

Suppose as a benchmark that  $\gamma = 0$ . We have the free parameters  $t, b$ . The left panel of Figure 2 captures the relocation patterns for the multinational (N,P or C), and it shows for which combinations of  $t$  and  $b$  the multinational has higher domestic output than the national firm (white regions), lower domestic output (black) or the same output (grey).

Relocation regimes in the  $(t, b)$ -diagram are similar to those in the  $(t, r)$ -diagram because more damaging pollutants (high  $b$ ) induce more regulation (high  $r$ ). As to the comparison between the multinational and the national firm, the figure leads to the following observation:<sup>16</sup>

**Result 1** *The following statements hold for the benchmark case  $\gamma = 0$ :*

- a) The multinational produces less than the national firm (i) for low  $t$  and intermediate values of  $b$  and (ii) for high  $t$  and low  $b$ .*
- b) The multinational produces more than the national firm for high values of  $t$  and intermediate values of  $b$ .*

In the remainder of this subsection, we provide the intuition for these observations. The results hold in general, and Figure 2 illustrates them for a specific parameterization. The left hand side of Figure 2 represents the case without lobbying; the right hand side shows how lobbying affects location structure and output.

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<sup>15</sup>The reverse ordering of welfare also occurs for an increase of  $\gamma$  starting from a strictly positive value. To focus the exposition, we start with  $\gamma = 0$ .

<sup>16</sup>Of course, when the environmental problem becomes sufficiently severe, both firms face regulation that chokes off pollution.

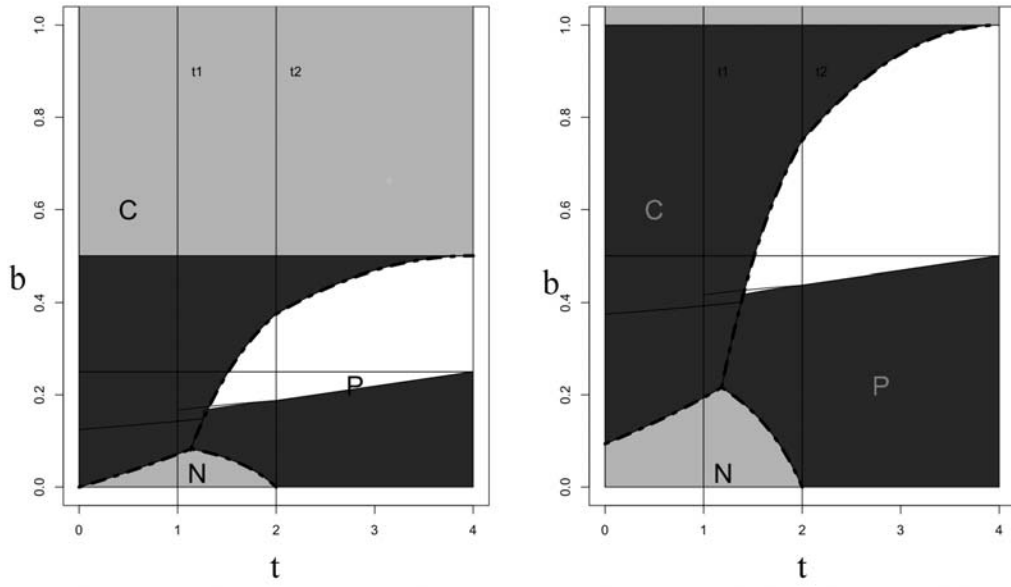


Figure 2: Locations and output ( $a = 3$ ,  $F = 3$ ): Left:  $\gamma = 0$ ; Right:  $\gamma = 0.5$ .  
 $MNE > Nat$ : white;  $MNE = Nat$ : grey;  $MNE < Nat$ : black.

To understand the intuition for a)(i), first consider the part of the complete relocation regime  $C$  where the national firm is active (low  $t$ , intermediate  $b$ ). There the multinational firm trivially has lower domestic output than the national firm, as it does not produce in the home country. For low transportation costs  $t$ , the reduction in consumer surplus from relocation is low, because the multinational will serve the home country from abroad without substantial price increases. Thus, the regulator is prepared to induce complete relocation of the multinational firm to improve environmental quality. With a national firm, the environmental benefits from shutting down would come at the costs of losing consumer surplus altogether, so that the regulator is more reluctant to close down the national firm.

As to a)(ii), for high  $t$ , there is partial relocation of the multinational. The left panel of Figure 2 shows that, in regime  $P$ , there is a critical level of  $b$ , below which the multinational produces a lower domestic output than the national firm. To understand this, we focus on the case  $t > t^2$ , so that there is partial relocation even for  $b = 0$ .<sup>17</sup> The multinational chooses partial relocation because transportation costs are high: Even for  $b = 0$ , when there is no regulation, it serves the foreign country from abroad. As the national firm lacks this option, it also produces its exports at home. As a result, the national firm produces and pollutes more than the multinational firm.

b) As in a)(ii), we continue to suppose that transportation costs are high. As the damage parameter increases, regulators first start regulating the national firm, because the benefits from regulating a firm with a larger home-country output are larger. As  $b$  increases within regime  $P$ , the regulation of the national firm eventually becomes so strict that it produces less output than the multinational firm which is still not regulated. The intuition is as follows: As environmental damages are large enough, the government wants the firm to close down export production to reduce pollution. Whereas the multinational firm does this even for  $r = 0$  (because it has the alternative of production abroad), the national firm only abolishes export production for sufficiently strict regulation,  $r \geq a - t$ . This leads to lower output of the national firm compared to the multinational that faces less regulation.

## 6.2 Increasing Influence of the Firm

We now assess the effects of a positive weight of the firm's profit in the welfare function ( $\gamma > 0$ ), reflecting greater importance of private benefits in the regulator's objective function. Clearly, regulation is reduced as  $\gamma$  increases, no matter whether the firm is national or multinational. The more interesting

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<sup>17</sup>For  $t^{1*} < t < t^2$ , the argument is similar.

question is whether it becomes more or less likely that the multinational faces less regulation than the national firm, and what the welfare effects are. The following observation which follows from Figure 2 is striking:

**Result 2** *As firm weight increases, (i) for low transportation costs, the area where the multinational firm produces lower output and pollution than the national firm is characterized by higher values of  $b$ ; (ii) for high transportation costs, the area where the multinational firm produces higher output and pollution than the national firm is characterized by higher  $b$ .*

Thus, for sufficiently dangerous pollutants as firm influence increases, the multinational tends to produce higher output and pollution than the national firm. We now provide the intuition for the result. The right panel of Figure 2 shows that an increase in  $\gamma$  has the following effects:

(i) The complete relocation regime shifts upwards, because multinational lobbying prevents restrictive regulation. However, as the national firm also has stronger weight than before, the region where they have to close down is also pushed upwards. As a result, for low  $t$ , both the lower and the upper bound of the region where the multinational firm produces strictly less output than the national firm moves up.

(ii) The second effect arises only in the partial relocation regime  $P$ , that is, for high  $t$ . The intuition is similar as in case (i). As the firms' weight grows, it face less regulation, no matter whether it is national or multinational. This leads to an upward shift in the regime boundaries. First, as in the case  $\gamma = 0$ , there is a critical level of  $b$  above which the multinational firm produces higher domestic output than the national firm. However, this requires that the national firm is regulated so heavily that exports are curbed, which will only happen for higher values of the damage parameters than for the case without lobbying ( $\gamma = 0$ ). Similarly, the upper boundary of the region where the multinational produces more than the national firm is determined by the point where the multinational completely relocates. Again, this point moves upwards as the multinational's influence increases.

## 7 Welfare

The results in the previous section strongly suggest that the welfare comparison between the national and the multinational firm is ambiguous. On the one hand, where the multinational is induced to relocate, local pollution will decline. On the other hand, relocation may lead to reductions in consumer surplus.



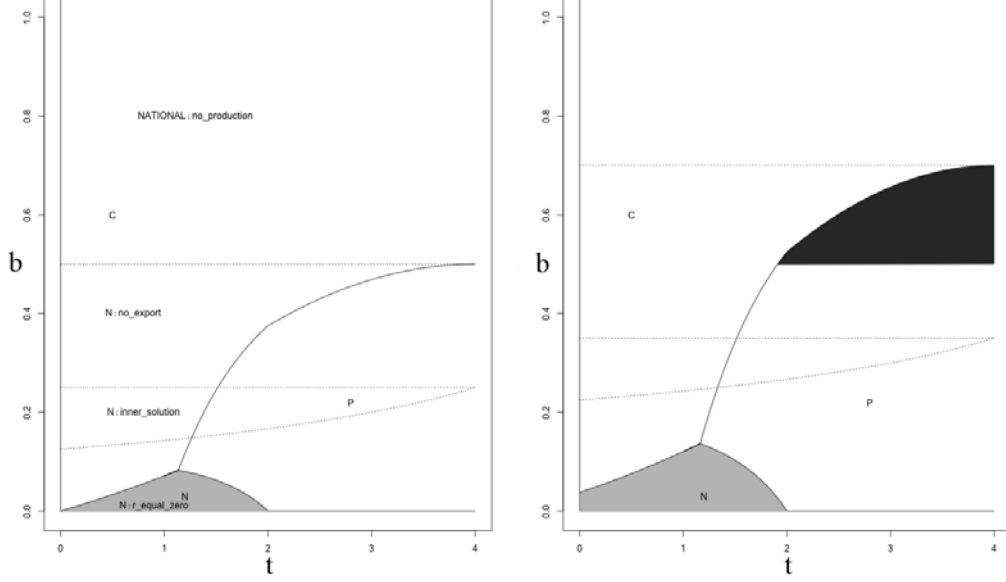


Figure 3: Welfare ( $a = 3$ ,  $F = 3$ ): Left:  $\gamma = 0$ ; Right:  $\gamma = 0.5$ . MNE>Nat: white; MNE=Nat: grey; MNE<Nat: black

However, by choosing regulation accordingly, the government can avoid relocation if desired. At first glance, it might therefore seem that a country is always better off with a multinational firm, because this adds the option of inducing exit of an undesired firm without losing consumer surplus completely. However, with a multinational firm the government loses the option to regulate the firm heavily and nevertheless have local production – the firm will vote with the feet when regulation gets too stringent.

In spite of these potential ambiguities, our model yields a very clear result: For  $\gamma = 0$ , a country is always better off when the monopolist is multinational rather than national, except for a small region where regulation and welfare are identical for both types of firms. The left hand side of Figure 3 represents the welfare comparison absent lobbying. Welfare is the same with a national or multinational firm if the multinational prefers to stay at home (grey area). For all other parameter regions, welfare is higher if the firm is a multinational. The intuition can be obtained from this figure, which is closely related to Figure 2. First, consider regime *C*: When the environmental damage is so substantial that the production of the national firm is choked off entirely whereas the multinational produces abroad, welfare is clearly higher with the multinational. This reflects the fact that the multinational still gen-

erates consumer surplus for the home country (without causing pollution at home). As the environmental damage parameter declines, the national firm is regulated less, so that it at least produces for the local market: Contrary to the multinational firm, the national firm therefore generates environmental damage, but because transportation costs are fairly small, so are the losses in consumer surplus from having a multinational rather than a local firm. In regime  $P$ , first consider low damage parameters. Then, contrary to the multinational firm, the national firm produces for both countries. The additional output for the foreign country creates more pollution than in the case of the multinational without generating more consumer surplus. As the pollution parameter increases, so that the government wants to curb exports of the national firm, strict regulation is necessary to induce this, so that the multinational firm generates higher consumer surplus without substantially more pollution.<sup>18</sup>

The situation changes when lobbying is taken into account. The right panel in Figure 3, which corresponds to the right panel in Figure 2, compares welfare (defined as pure consumer surplus minus damages) for the national and the multinational firm when lobbying occurs ( $\gamma = 0.5$ ). The figure shows that there now is a region where welfare with a multinational firm is lower than with a national firm (shaded dark). In this region, there is partial relocation, and the multinational firm produces more than the national firm. As discussed in Section 6, the multinational firm is regulated less than the national firm because strict regulation of the national firm is necessary to prevent export production from the home country. This increases environmental damages and reduces welfare compared to the national firm. We sum up the observations from Figure 3 as follows.

**Result 3** *For  $\gamma = 0$ , welfare is always higher with a multinational firm than with a national firm. As  $\gamma$  increases, parameter regions emerge where welfare is lower with the multinational.*

This result illustrates the effects of lobbying on welfare: Even though our setting is biased in the sense that a consumer-surplus maximizing government is always better off with a multinational, this changes with lobbying: There are parameter regions (with fairly high environmental damage parameter) where the increasing influence activities reverse the welfare comparison.

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<sup>18</sup>We want to point out the clear result for  $\gamma = 0$  is due to the model specification where both the consumer surplus and the damage function are quadratic in output. For other functional forms, the area where welfare with the multinational is lower than with the national firm may already emerge for  $\gamma = 0$ .

## 8 Conclusions and Generalization

In a simple monopoly model, we investigate whether a national or multinational firm is regulated more strictly and how lobbying influences welfare. One might be concerned that the results of the simple monopoly depend on the very special assumptions. In Appendix F, we show that this is not the case. We introduce a general model with assumptions on the demand structure, the nature of regulation and the damage function which are compatible with our specific example. We allow more general demand functions, damage functions, transportation costs and regulation. We show that, under very general assumptions the location choices of the firm have the same qualitative properties as in Section 4. We then go on to show that the comparison between national and multinational firms identified in Section 6.1 is still valid in this more general setting.

The model demonstrates that for low transportation costs, governments choose regulation so that the multinational exercises the option of relocation when environmental damages are high (and hence regulation becomes stricter); the national firm then produces and pollutes at least as much as the multinational. As transportation costs increase, a large parameter region exists where the multinational pollutes more than the national firm. This requires that environmental damages are neither too high nor too low. In this case, the multinational faces less regulation than the national firm and produces a higher output. The government uses regulation policy to render national production for export unprofitable, because it decreases aggregate welfare.

Consumer surplus net of environmental damages is always higher for a multinational firm when the regulator cares only about consumers. In this case, the regulator can easily avoid local pollution damages by driving the multinational out of the market and relying on imports, given that this is preferable from a welfare perspective. This option is not available with a national firm, since imports are not available as a substitute for local production. Increasing lobbying influence of the firm does not change this picture in a qualitative sense. However, the region where the multinational produces and pollutes more now involves pollutants with higher damage parameters.

Thus lobbying may have worse effects on welfare if the firm is able to relocate instead of being purely national. Lobbying leads to less regulation with both types of firms. Yet with high transportation costs and intermediate environmental damages, the increase of lobbying activities leads to regulation that is too lax if the firm is able to relocate.

Are multinationals bad from a lobbying perspective because they lead to pollution havens? At least from a perspective of a small open economy,

there are potential welfare gains from facing multinational rather than national firms. This is due to the ability to exert a negative external effect on other countries and to drive unwanted production out of the country without the need to accept a high loss in consumer surplus (when transportation costs are low). However, there are also potential welfare losses from the relocation option of a multinational. With high transportation costs and strong environmental pollution, lobbying leads to lax regulation with the presence of a multinational and more local production. Compared to a national firm, this tends to decrease welfare.

## Appendices

### A The lobbying game

We first show that the regulation level resulting from the game described in Section 3.2 maximizes a weighted sum of welfare and profits.

**Proposition 3** *There is a subgame perfect equilibrium  $r^*, C^{r^*}(r)$  of the lobbying game such that*

$$r^* = \operatorname{argmax}_r \Pi(r) - \frac{1}{\beta} [\widehat{W}(r^0) - \widehat{W}(r)].$$

and

$$C^{r^*}(r) = \begin{cases} \frac{1}{\beta} [\widehat{W}(r^0) - \widehat{W}(r)] & \text{if } r = r^*. \\ \frac{1}{\beta} [\widehat{W}(r^0) - \widehat{W}(r)] - \varepsilon(r) & \text{if } r \neq r^* \end{cases}.$$

$\varepsilon$  is differentiable and has the following properties:

$$\varepsilon(r^*) = 0 = \varepsilon(r^0); \varepsilon(r) > 0 \quad \forall r \neq r^*, r^0; \varepsilon(r) \leq \frac{1}{\beta} [\widehat{W}(r^0) - \widehat{W}(r)]. \quad (4)$$

**Proof:** In the second stage, for any contribution schedule  $C(\cdot)$ , the politician chooses a policy  $r$  that maximizes  $\widehat{W}(r) + \beta C(r)$ . By choosing  $r^0$ , the politician can obtain  $\widehat{W}(r^0) + \beta C(r^0)$ . Here,  $C(r^0) = 0$ , as the regulation level  $r^0$  is by definition chosen as being welfare-maximizing without lobbying payments. Thus, if a regulation  $\tilde{r} \neq r^0$  is to be induced, it is necessary that

$$C(\tilde{r}) \geq \frac{1}{\beta} (\widehat{W}(r^0) - \widehat{W}(\tilde{r})).$$

Thus, any desired location  $\tilde{r}$  can be induced with the following scheme:

$$C^{\tilde{r}}(r) = \begin{cases} \frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(r) \right] & \text{if } r = \tilde{r} \\ \frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(r) \right] - \varepsilon(r) & \text{otherwise.} \end{cases}$$

with  $\varepsilon(\tilde{r}) = 0 = \varepsilon(r^0)$ ;  $\varepsilon(r) > 0 \forall r \neq \tilde{r}, r^0$ ;  $\varepsilon(r) \leq \frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(r) \right]$ .

Facing  $C^{\tilde{r}}(r)$ , the politician obtains utility levels  $\widehat{W}(r^0)$  for  $r^0$  and  $\tilde{r}$  and lower utility levels for all other values of  $r$ . Any desired regulation level  $\tilde{r}$  can be induced at minimal costs  $\frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(\tilde{r}) \right]$ . Thus, the firm effectively chooses  $r$  as

$$r^* = \arg \max_r \Pi(r) - \frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(r) \right].$$

The corresponding contribution schedule is  $C^{r^*}$ . ■

The proposition has an intuitive implication.

**Result 4** *The regulation level chosen in the lobbying game is*

$$\arg \max_r \widehat{W}(r) + \beta \Pi(r)$$

**Proof:** By Proposition 3,

$$r^* = \arg \max_r \Pi(r) - \frac{1}{\beta} \left[ \widehat{W}(r^0) - \widehat{W}(r) \right].$$

Thus

$$r^* = \arg \max_r \Pi(r) + \frac{1}{\beta} \widehat{W}(r) = \arg \max_r \beta \Pi(r) + \widehat{W}(r).$$

■

Thus, regulation maximizes a weighted sum of welfare and firm profits.

## B The location decisions of the multinational

### B.1 Deriving Equation (2)

Using (1), profits in the different locations are

$$\Pi^N = p_1 x_1^1 + p_2 x_2^1 - r(x_1^1 + x_2^1) - t x_2^1 \quad (5)$$

$$\Pi^P = p_1 x_1^1 + p_2 x_2^2 - r x_1^1 - F \quad (6)$$

$$\Pi^C = p_1 x_1^2 + p_2 x_2^2 - t x_1^2 - F.$$

Simple calculations show that the optimal output levels are

$$\begin{aligned}
x_1^1 &= \max\left(\frac{a-r}{2}, 0\right), x_2^1 = \max\left(\frac{a-r-t}{2}, 0\right) \text{ in regime } N \\
x_1^1 &= \frac{a-r}{2}, x_2^2 = \frac{a}{2} \text{ in regime } P \\
x_1^2 &= \frac{a-t}{2}, x_2^2 = \frac{a}{2} \text{ in regime } C.
\end{aligned} \tag{7}$$

Inserting these choices into (5), we obtain (2).

## B.2 Locational Choices

We now derive locational choices (3). Using (2), we first make pairwise comparisons of profits in the different regimes:

$$\begin{aligned}
\Pi^N > \Pi^P &\Rightarrow \begin{cases} r^2 + t^2 + 2rt - 2ar - 2at + 4F > 0 & \text{if } r \leq a - t \\ -a^2 + 4F > 0 & \text{if } a - t < r \end{cases} \\
\Pi^P > \Pi^C &\Rightarrow \begin{cases} t > r & \text{if } r \leq a \\ \text{never} & \text{if } a < r \end{cases} \\
\Pi^N > \Pi^C &\Rightarrow \begin{cases} r^2 + rt - 2ar + 2F > 0 & \text{if } r \leq a - t \\ r^2 - t^2 - a^2 + 2at - 2ar + 4F > 0 & \text{if } a - t < r \leq a \\ 0 > 2a^2 - 2at + t^2 - 4F & \text{if } a < r \end{cases}
\end{aligned}$$

For regime  $N$  to be chosen, we need  $\Pi^N > \Pi^P \wedge \Pi^N > \Pi^C$ . For  $r \leq a - t$  we therefore need :

$$r^2 + t^2 + 2rt - 2ar - 2at + 4F > 0 \wedge r^2 + rt - 2ar + 2F > 0.$$

For  $a - t < r \leq a$ ,  $N$  is optimal if

$$-a^2 + 4F > 0 \wedge r^2 - t^2 - a^2 + 2at - 2ar + 4F > 0.$$

For  $r > a$ , the condition becomes

$$-a^2 + 4F > 0 \wedge 0 > (a - t)^2 + a^2 - 4F.$$

Due to assumption 1(ii),  $a^2 > 4F$ , the second and the third case cannot occur. For the first case ( $r \leq a - t$ ), simple derivations show that the two conditions can be written as

$$r < \min\left\{a - t - \sqrt{a^2 - 4F}, a - \frac{t}{2} - \frac{1}{2}\sqrt{(t - 2a)^2 - 8F}\right\}.$$

Defining

$$r_1 \equiv a - t - \sqrt{a^2 - 4F} \text{ and } r_2 \equiv a - \frac{t}{2} - \frac{1}{2}\sqrt{(t - 2a)^2 - 8F}, \quad (8)$$

the first statement in (3) follows.

For regime  $P$  to be chosen, we need  $\Pi^P > \Pi^N \wedge \Pi^P > \Pi^C$ . For  $r \leq a - t$ , we thus require

$$r^2 + t^2 + 2rt - 2ar - 2at + 4F < 0 \wedge t > r.$$

For  $r > a - t$ , the condition for  $P$  to be optimal is

$$-a^2 + 4F < 0 \wedge t > r.$$

Again, straightforward calculations show that location  $P$  is chosen in the following cases:

$$\begin{aligned} \text{for } r \leq a - t & : a - t - \sqrt{a^2 - 4F} < r < t \\ \text{for } r > a - t & : -a^2 + 4F < 0 \wedge r < t \end{aligned}$$

Using  $a^2 - 4F > 0$  and the fact that  $C$  is chosen in the remaining cases, where neither  $N$  nor  $P$  will be chosen, leads to the equations (3) for  $l(r)$ .

### B.3 Proof of Lemma 1

Define  $t^1 = \frac{a - \sqrt{a^2 - 4F}}{2}$  and  $t^2 = a - \sqrt{a^2 - 4F}$ . Using (3) and (8): regimes  $N$ ,  $P$  and  $C$  intersect at  $t^1$ , and  $t^2$  corresponds to the value where the “ $\Pi^N = \Pi^P$ ”-line intersects with the  $x$ -axis.

## C The Expressions for Welfare

Simple calculations show:

$$\begin{aligned} K^N &= \int_0^{x_1^1} (a - q) \mathbf{d}q - (a - x_1^1)x_1^1 = \frac{(x_1^1)^2}{2} \\ K^P &= \int_0^{x_1^1} (a - q) \mathbf{d}q - (a - x_1^1)x_1^1 = \frac{(x_1^1)^2}{2} \\ K^C &= \int_0^{x_1^2} (a - q) \mathbf{d}q - (a - x_1^2)x_1^2 = \frac{(x_1^2)^2}{2} \end{aligned} \quad (9)$$

$$\begin{aligned}
D^N &= b(x_1^1 + x_2^1)^2 \\
D^P &= b(x_1^1)^2 \\
D^C &= 0
\end{aligned} \tag{10}$$

The welfare levels in the different locational regimes are then (taking  $\Pi$  from (5)):

$$\begin{aligned}
W^N &= \frac{(x_1^1)^2}{2} + \gamma[(a - x_1^1)x_1^1 + (a - x_2^1)x_2^1 - r(x_1^1 + x_2^1) - tx_2^1] \\
&\quad - b(x_1^1 + x_2^1)^2 \\
W^P &= \frac{(x_1^1)^2}{2} + \gamma[(a - x_1^1)x_1^1 + (a - x_2^2)x_2^2 - r(x_1^1) - F] - b(x_1^1)^2 \\
W^C &= \frac{(x_1^2)^2}{2} + \gamma[(a - x_1^2)x_1^2 + (a - x_2^2)x_2^2 - t(x_1^2) - F]
\end{aligned} \tag{11}$$

Inserting the values for the output from above (equation (7)) and discerning the cases as above gives <sup>19</sup>:

$$\begin{aligned}
W^N(r) &= \begin{cases} \text{if } r \leq a - t : & \frac{\gamma}{4} [2a^2 + 2r^2 + t^2 + 2rt - 4ar - 2at] \\
& + \frac{1}{8}(a - r)^2 - \frac{b}{4}(2a - 2r - t)^2 \\
\text{if } a - t < r \leq a : & \frac{\gamma}{4}(a - r)^2 + \frac{1}{8}(a - r)^2 - \frac{b}{4}(a - r)^2 \\
\text{if } a < r : & 0 \end{cases} \\
W^P(r) &= \begin{cases} \text{if } r \leq a : & \frac{\gamma}{4} [2a^2 + r^2 - 2ar - 4F] + \frac{1}{8}(a - r)^2 \\
& - \frac{b}{4}(a - r)^2 \end{cases} \\
W^C(r) &= \frac{\gamma}{4} [2a^2 + t^2 - 2at - 4F] + \frac{1}{8}(a - t)^2.
\end{aligned} \tag{12}$$

## D Regulation of national firms

### Proof of Proposition 1

(a) The welfare levels corresponding to  $r \geq a$  (No Production),  $r \leq a - t$  (Full Production) and  $a - t \leq r \leq a$  (No Exports) are given in equation (12). We first show that the optimal  $r$  and the corresponding welfare levels correspond to the values shown in Table 1.

(a1) Clearly, for  $r \geq a$ , welfare is 0, independent of  $r$ .

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<sup>19</sup>In regime P, we ignore the case  $r > a$ : In this case, the home market would not be served, so that complete relocation is always preferred.



(a2) For  $r \leq a - t$ , firms produce both for both markets. Using the F.O.C for unconstrained maximization of  $W^N(r)$ ,

$$r = \frac{a(-4\gamma - 1 + 8b) + t(-4b + 2\gamma)}{-4\gamma - 1 + 8b}$$

is a candidate interior solution. However, this candidate is only in  $[0, a - t]$  if  $2b - \frac{1}{2} \leq \gamma < 2b - \frac{a}{2(2a-t)}$ . For  $\gamma < 2b - \frac{1}{2}$ ,  $W^N(r)$  is increasing in  $r$  on  $[0, a - t]$ , so that the optimum is  $r = a - t$ . For  $\gamma > 2b - \frac{a}{2(2a-t)}$ ,  $W^N(r)$  is decreasing in  $r$ , so the optimum is  $r = 0$ . Table 1 also contains the resulting welfare levels.

(a3) For  $a - t \leq r \leq a$ , it turns out that  $W^N(r)$  is always monotone, resulting in an optimum  $r = a$  if  $\gamma < b - \frac{1}{2}$  and  $r = a - t$  if  $\gamma > b - \frac{1}{2}$ .

(b) Next, we compare welfare in the candidate solutions. (b1) If  $\gamma < \gamma^1 \equiv b - \frac{1}{2}$ , the optimal solution is  $r = a - t$  in the full production regime and it is  $r = a$  in the no exports regime. Comparing the expressions for welfare, we obtain that  $r = a$  and  $W = 0$ . Hence, part (i) of the result follows.

(b2) If  $b - \frac{1}{2} < \gamma < \gamma^2 \equiv 2b - \frac{1}{2}$ , the candidate optimum in both regimes is  $r = a - t$ . Hence, part (ii) of the result follows.

(b3) If  $2b - \frac{1}{2} \leq \gamma < \gamma^3 \equiv 2b - \frac{a}{2(2a-t)}$ , the optimum in the full production regime is given by the interior solution. It has to be compared with the optimum in the No Exports regime ( $r = a - t$ ). Using the corresponding expressions in Table 1, it turns out that the full production optimum is superior.

(b4) If  $\gamma > \gamma^3$ , the optimum in the full production regime is  $r = 0$ , the optimum in the No Exports regime is  $r = a - t$ . Using the corresponding expressions for welfare in Table 1, it follows that full production is superior. Together with (b3), this implies Part (iii) of the result.

range of $\gamma$	$r =$	$W^N =$
$\gamma < b - \frac{1}{2}$	$a$	0
$b - \frac{1}{2} < \gamma < 2b - \frac{1}{2}$	$a - t$	$t^2(\frac{\gamma}{4} + \frac{1}{8} - \frac{b}{4})$
$2b - \frac{1}{2} \leq \gamma < 2b - \frac{a}{2(2a-t)}$	$\frac{a(-4\gamma-1+8b)+t(-4b+2\gamma)}{-4\gamma-1+8b}$	$\frac{t^1}{(1+2\omega)^2} [\frac{\gamma}{4}(2\omega^2 + 2\omega + 1) + \frac{\omega^2}{8} - \frac{b}{4}]$
$2b - \frac{a}{2(2a-t)} < \gamma$	0	$(2a^2 + t(t - 2a))\frac{\gamma}{4} + a^2\frac{1}{8} - \frac{b}{4}(t - 2a)^2$

Table 1: Optimal values for the regulation  $r$  and corresponding welfare levels for the national firm ( $\omega := -4b + 2\gamma$ )

## E Regulation of multinational firms

The proof of Proposition 2 requires several preliminary results.

**Lemma 2:** *Welfare under complete relocation is*

$$W^C = \left( \frac{\gamma}{4} + \frac{1}{8} \right) (a - t)^2 + \frac{\gamma}{4} (a^2 - 4F).$$

*The corresponding minimal regulation is  $r^C = a - \frac{t}{2} - \frac{1}{2} \sqrt{-8F - 4at + 4a^2 + t^2}$  or  $r^C = t$ .*

The result follows directly from (12). Intuitively, as the firm serves both countries from abroad, there is no home country pollution. The home country consumer surplus has to be calculated taking into account the transportation costs  $t$ , and similarly for total profits. As  $W^C$  is independent of regulation, any value of  $r$  inducing complete relocation can be chosen. A natural candidate is the lowest possible value that induces  $C$ , thus the lower boundary of the complete relocation region in the  $(t, r)$ -graph. These values for  $r$  can be taken from Appendix B.

**Lemma 3:** (i) *If  $\gamma < b - \frac{1}{2}$  the constrained optimal choice of  $r$  in  $P$  lies on the upper boundary of  $P$  ( $r = t$ ). The resulting welfare level is*

$$W^P = \left( \frac{\gamma}{4} + \frac{1}{8} \right) (a - t)^2 + \frac{\gamma}{4} (a^2 - 4F) - \frac{b}{4} (a - t)^2$$

(ii) *If  $\gamma > b - \frac{1}{2}$  the constrained optimal choice of  $r$  in  $P$  lies on the lower boundary of  $P$ , which is  $r = a - t - \sqrt{a^2 - 4F}$  in NPC and  $r = 0$  in PC. The corresponding welfare levels are*

$$W^{P-NPC} = \left( \frac{\gamma}{4} + \frac{1}{8} - \frac{b}{4} \right) \left( t + \sqrt{a^2 - 4F} \right)^2 + \frac{\gamma}{4} (a^2 - 4F) \quad (13)$$

$$W^{P-PC} = \left( \frac{\gamma}{4} + \frac{1}{8} - \frac{b}{4} \right) a^2 + \frac{\gamma}{4} (a^2 - 4F) \quad (14)$$

**Proof of Lemma 3:** The derivative of  $W^P(r)$  is  $\frac{1}{4} (r - a) (2\gamma - 2b + 1)$ . In regime P,  $r \leq a$ . Therefore,  $W^P$  is monotone increasing in  $r$  for  $\gamma < b - \frac{1}{2}$  and decreasing for  $\gamma > b - \frac{1}{2}$ . Thus in the former case the constrained optimum in P lies on the upper boundary of P, in the latter case it lies on the lower boundary (which is at  $a - t - \sqrt{a^2 - 4F}$  or at 0).

We use these results and Proposition 1 to prove Proposition 2.

**Proof of Proposition 2:**

We define the critical levels of  $\gamma$  as follows:

$$\begin{aligned}\gamma^{C1} &\equiv \max \left\{ \frac{-a + 8ab - 4bt}{4a - 2t}, \frac{(t - 2a)(t + 2b(t - 2a))}{8F} \right\} \\ \gamma^{C2} &\equiv \max \left\{ \begin{aligned} &b - \frac{1}{2} \\ &\min \left( \frac{b(t + \sqrt{a^2 - 4F})^2}{t\sqrt{a^2 - 4F} - 2F + at} - \frac{1}{2}, 2b - \frac{a}{2(a-t)} \right) \\ &\min \left( \frac{b(t + \sqrt{a^2 - 4F})^2}{t\sqrt{a^2 - 4F} - 2F + at} - \frac{1}{2}, \frac{2b(2a-t)^2 - t(2a-t)}{8F} \right) \end{aligned} \right\} \\ \gamma^{P2} &\equiv \max \left\{ \begin{aligned} &2b - \frac{a}{2(a-t)}, \\ &\frac{2b(2t\sqrt{a^2 - 4F} + 4at - 3a^2 - 4F) - (t^2 + 2t\sqrt{a^2 - 4F} - 4F)}{2(2t\sqrt{a^2 - 4F} + 2at - 8F)} \end{aligned} \right\} \\ \gamma^{C3} &\equiv \frac{ba^2}{t(2a - t)} - \frac{1}{2}\end{aligned}$$

(i) We show that for  $t < t^1$  complete relocation arises if and only if  $\gamma < \max \left\{ \frac{-a + 8ab - 4bt}{4a - 2t}, \frac{(t - 2a)(t + 2b(t - 2a))}{8F} \right\}$ . We distinguish four cases:

(a) Let  $\gamma < b - \frac{1}{2}$ . In this case,  $W^N = 0$  according to Proposition 1, so that  $W^C > W^N$  and complete relocation is optimal.

(b) Let  $b - \frac{1}{2} < \gamma < 2b - \frac{1}{2}$ : The optimality condition for the national firm involves  $r = a - t$  and the resulting welfare level is given by  $t^2 \left( \frac{\gamma}{4} + \frac{1}{8} - \frac{b}{4} \right)$ . The resulting condition for  $W^C > W^N$  is

$$-\frac{bt^2}{4} < (a^2 - 2at)\left(\frac{\gamma}{4} + \frac{1}{8}\right) + \frac{\gamma}{4}(a^2 - 4F).$$

Using  $t < \frac{a - \sqrt{a^2 - 4F}}{2}$  and thus  $a^2 - 2at > 0$ , we derive that the inequality always holds.

(c) For  $2b - \frac{1}{2} < \gamma < \frac{-a + 8ab - 4bt}{4a - 2t}$ , the national firm is optimally regulated so that it produces for both countries. Again, we have  $W^C > W^N$  and optimality of  $C$ .

(d) Finally, for  $\frac{-a + 8ab - 4bt}{4a - 2t} < \gamma$ , the optimal regulation of the national firm is  $r = 0$ . It turns out that  $W^C > W^N$  and complete relocation is optimal in case  $\gamma < \frac{(t - 2a)(t + 2b(t - 2a))}{8F}$ , otherwise no relocation  $N$  is optimal, i.e.  $W^N > W^C$ .

(ii) We have to show that for  $t^1 < t < t^2$  the location choice is made as described in the proposition. We distinguish three cases:

(a) For  $\gamma < b - \frac{1}{2}$ , comparing  $W^P$  and  $W^C$  from Lemma 2 above and  $W^N$  from table 1 shows that  $C$  is optimal.

(b) For  $b - \frac{1}{2} < \gamma < 2b - \frac{a}{2(2a-t)}$ , comparison of the relevant expressions for  $W^N$  and  $W^P$  from above shows that always  $W^P > W^N$  and that thus  $N$  is never chosen. Comparing  $W^P$  and  $W^C$  leads to  $C$  being optimal for  $\gamma < \frac{b(t+\sqrt{a^2-4F})^2}{2at+2t\sqrt{a^2-4F}-4F} - \frac{1}{2}$  and  $P$  for the opposite (calculations are straightforward but tedious; cf. notes p22-25).

(c) For  $2b - \frac{a}{2(2a-t)} < \gamma$ , comparison of all three location choices is necessary. Pairwise comparison of the relevant expressions for welfare yields  $W^C > W^P \Leftrightarrow \gamma < \frac{b(t+\sqrt{a^2-4F})^2}{4a-2t} - \frac{1}{2}$ ,  $W^C > W^N \Leftrightarrow \gamma < \frac{2b(2a-t)^2-t(2a-t)}{8F}$ , and  $W^P > W^N \Leftrightarrow \gamma < \frac{2b(2t\sqrt{a^2-4F}+4at-3a^2-4F)}{2(2t\sqrt{a^2-4F}+2at-8F)} - \frac{(t^2+2t\sqrt{a^2-4F}-4F)}{2(2t\sqrt{a^2-4F}+2at-8F)}$ .

Combining all these conditions for optimality of a certain regime yields part (ii) of the proposition.

(iii) We have to show that, for  $t > t^2$ , there is complete relocation if and only if  $\gamma \leq \gamma^{C3} \equiv \frac{ba^2}{t(2a-t)} - \frac{1}{2}$ .

(a) For  $\gamma < b - \frac{1}{2}$ , Lemma 3(i) shows that the optimum in P is on the upper boundary of P and the welfare level is given by the expression for  $W^P$  given there. Comparison with the expression for  $W^C$  from Lemma 2 above shows that  $W^C > W^P$ .

(b) For  $\gamma > b - \frac{1}{2}$ , welfare under partial relocation is given by equation (14). It follows that  $W^C > W^P$  for  $b > \frac{(2\gamma+1)t(2a-t)}{2a^2}$  (as  $a^2 > 2at - t^2$ , this is compatible with the first condition on  $\gamma$ :  $\gamma > b - \frac{1}{2}$ ). Rearranging terms, this translates into  $C$  for  $b - \frac{1}{2} < \gamma < \frac{ba^2}{t(2a-t)} - \frac{1}{2}$  and  $P$  for  $\frac{ba^2}{t(2a-t)} - \frac{1}{2} < \gamma$  (as  $(a-t)^2 > 0$  we have  $b - \frac{1}{2} < \frac{ba^2}{t(2a-t)} - \frac{1}{2}$  and these ranges are possible).

## F The General Model

We now show that the main insights of our analysis hold much more generally. We work with assumptions on the demand structure, the nature of regulation and the damage function which are compatible with our specific example. As before, we suppose there are two countries  $i = 1, 2$  and one firm, which originally has a plant in country 1. However, regulation in country 2 can be positive as well. We denote regulation levels as  $r_i$ . There are parameters capturing market demand  $a > 0$ , transportation costs  $t \geq 0$ , relocation costs  $F \geq 0$  and environmental damages  $b \geq 0$ . Let  $\theta = (a, b, t, F)$ . The firm has three options for location decisions, namely “no relocation” (“N”), i.e. it produces in country 1 only, “complete relocation” (“C”), i.e. it produces in country 2 only, and “partial relocation” (“P”), where production for country 1 takes place in country 1, production for country 2 takes place in country

two. We use the notation  $l(r_1, r_2; \theta)$  to denote locational decisions N, P or C.

## F.1 Profits and Locational Choices

We let  $\pi_{ij}(r_i; a, t)$  denote the optimal profits of a firm that serves country  $j$  from country  $i$  (gross of relocation costs); total gross profits of a firm having taken the locational decision  $l$  are thus  $\pi_l(r_i, r_j; a, t) \equiv \pi_{i1}(r_i; a, t) + \pi_{j2}(r_j; a, t)$ , with  $i = 1 = j$  for  $l = N$ ,  $i = 2 = j$  for  $l = C$ , and  $i = 1, j = 2$  for  $l = P$ . We let  $x_{ij}(r_i; a, t)$ ,  $x_l(r_i, r_j; a, t)$  denote the corresponding outputs.  $\Pi_l(r_i, r_j; a, t) = \pi_l(r_i, r_j; a, t) - F$  denotes net profits.

**Assumption 2** *Let  $i = 1, 2$ .*

- (a) *For  $i, j = 1, 2$  and all  $a > 0; t > 0$ , there exists an  $r^{\max} = r^{\max}(a, t)$  such that  $x_{ij}(r_i; a, t) \equiv 0$  and  $\pi_{ij}(r_i; a, t) \equiv 0$  for  $r_i \geq r^{\max}$ .*
- (b) *For  $r_i \leq r^{\max}$ ,  $\pi_{ij}$  and  $x_{ij}$  are (i) decreasing in  $r_i$  and (ii) increasing in  $a$ ; (iii) decreasing in  $t$  for  $i \neq j$  and independent of  $t$  for  $i = j$ . As long as  $x_{ij} > 0$ , the statements can be replaced with “strictly increasing” and “strictly decreasing”, respectively.*
- (c) (i)  $x_{ij}(r_i; a, t) \equiv x_{ji}(r_j; a, t)$  and  $\pi_{ij}(r_i; a, t) \equiv \pi_{ji}(r_j; a, t)$   
(ii)  $x_{1j}(r_1; a, 0) \equiv x_{2j}(r_2; a, 0)$  and  $\pi_{1j}(r_1; a, 0) \equiv \pi_{2j}(r_2; a, 0)$  for  $r_1 = r_2$ ,
- (d)  $x_{ij}$  and  $\pi_{ij}$  are continuous in all arguments.
- (e)  $\lim_{t \rightarrow \infty} \pi_{ij}(r_i; a, t) = \pi_{ji}(r_j; a, t) = 0$  (for  $i \neq j$ ),  
 $\lim_{a \rightarrow 0} \pi_{ij}(r_i; a, t) = 0$  for  $j = 1, 2$ .
- (f)  $x_{ii}(0; a, t) > 0$  and  $\pi_{ii}(0; a, t) > 0$ .

These assumptions are fairly general. (a) states that there is a prohibitive level of regulation; (b) stipulates that outputs and profits react to changes of regulation and to market parameters in the expected way; (c) requires that countries and firms are symmetric and differ only according to the type of regulation. Assumptions (d) and (e) are innocuous regularity properties; (f) states that outputs and profits are positive without regulation.

We show that the qualitative properties of Figure 1 hold if Assumption 2 does.

**Proposition 4** (i) *For all  $r_2 \geq 0$  and all  $\theta$ ,  $l(0, r_2; \theta) \neq C$ .*

(ii) *For all  $(r_2; \theta)$  there exists  $r_1^* > 0$  and  $t^* > 0$  such that  $\forall r_1 < r_1^*$  and  $\forall t < t^*$ ,  $l(r_1, r_2; \theta) = N$ .*

(iii) *For all  $(r_2; \theta)$  such that  $\pi_{22}(r_2; a, t) \geq F$  there exists  $r^* = r^*(r_2; \theta) > 0$  such that  $l(r_1, r_2; \theta) = C$  for  $r_1 > r^*$ .*

(iv) *For all  $(r_1, r_2, a, F)$  there exists a  $t^* > 0$  such that  $l(r_1, r_2; \theta) \neq P$  for  $t < t^*$ . If  $\pi_{22}(r_2; a, t) \geq F$ , then there is a  $t^{**}$  such that  $l(r_1, r_2; \theta) \neq N$  for  $t > t^{**}$ .*

**Proof:** (i) We have to show that serving country 1 from country 2 is never worthwhile for  $r_1 = 0$ , i.e.  $\pi_{11}(0; a, t) \geq \pi_{21}(r_2; a, t)$  for all  $r_2$ . By Assumption 2c(ii)  $\pi_{11}(0; a, 0) = \pi_{21}(0; a, 0)$ . By b(i)  $\pi_{21}(r_2; a, 0) \leq \pi_{21}(0; a, 0)$  for all  $r_2 \geq 0$ . Thus  $\pi_{11}(0; a, 0) \geq \pi_{21}(r_2; a, 0)$ . By b(iii)  $\pi_{11}(0; a, 0) = \pi_{11}(0; a, t)$  and  $\pi_{21}(r_2; a, 0) \geq \pi_{21}(r_2; a, t)$ . Hence  $\pi_{11}(0; a, t) \geq \pi_{21}(r_2; a, t)$ .  
(ii) By (cii)  $\pi_{11}(0; a, 0) = \pi_{21}(0; a, 0)$ , therefore by Assumption (bi),  $\pi_{11}(0; a, 0) \geq \pi_{21}(r_2; a, 0)$  for all  $r_2$ . Similarly,  $\pi_{12}(0; a, 0) \geq \pi_{22}(r_2; a, 0)$ . Because  $F > 0$ , therefore, relocation is never worthwhile for  $r_1 = t = 0$ . By continuity (d), the result also holds if  $r_1$  and  $t$  are sufficiently small.  
(iii) By Assumption 2(a),  $\pi_{1j}(r_1; a, t) = 0$  for  $r_1 \geq r^{\max}$  and  $j = 1, 2$ , so that production in country 1 is not worthwhile. However, as  $\pi_{22}(r_2; a, t) \geq F$  by assumption, a firm that relocates complete obtains a positive profit. Thus, complete relocation is worthwhile for  $r_1 \geq r^{\max}$ .  
(iv) First, we show that, if partial relocation is better than no relocation and  $t = 0$ , then complete relocation is better than partial relocation: Partial relocation necessarily requires  $\pi_{12}(r_1; a, 0) < \pi_{22}(r_2; a, 0)$ . By Assumption 2(c) and (biii),  $\pi_{12}(r_1; a, 0) = \pi_{11}(r_1; a, 0)$  and  $\pi_{22}(r_2; a, 0) = \pi_{21}(r_2; a, 0)$ . Therefore  $\pi_{11}(r_1; a, 0) < \pi_{21}(r_2; a, 0)$ , so that serving country 1 from abroad is more profitable than serving it from home. By continuity (assumption 2d), there then exists a  $t^* > 0$  such that complete relocation is optimal for  $t < t^*$ . Fix  $r_2, a, F$  and  $t$ . By Assumption 2(e),  $\lim_{t \rightarrow \infty} \pi_{12}(r_1; a, t) = 0$ . Because  $\pi_{22}(r_2; a, t) \geq F$ , partial or complete relocation is optimal for sufficiently high  $t$  and no relocation is never chosen.

The proposition reflects the relocation structure of our specific model in a more general context. As to (i), complete relocation does not occur when there is no regulation in the home country.<sup>20</sup> (ii) says that, if regulation and transportation costs are small, no relocation occurs. By (iii), provided that foreign country regulation is not too strict to prevent positive profits net of relocation costs, complete relocation occurs for sufficiently high regulation in the home country. (iv) states that whether relocation is partial or complete depends on the interaction between regulation and transportation costs: For low transportation costs, partial relocation is never optimal, while for higher transportation costs partial relocation can be optimal and no relocation is never chosen.

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<sup>20</sup>Note that in this case partial relocation may occur due to high transportation costs.

## F.2 The Choice of Regulation

We now introduce additional assumptions so that we can address the choice of regulation.

**Assumption 3** (a) *The regulator maximizes a weighted sum of consumer surplus (minus damages) and profits.*

(b) *Consumer surplus is a strictly increasing function of  $x_i$ .*

(c) *Damages are continuous, weakly increasing functions of  $x_i$  and  $b$ . For  $b > 0$ , they are strictly increasing in  $x_i$ ; for positive  $x_i$ , they are strictly increasing in  $b$ . For  $b = 0$ , damages are 0 for all  $x_i$  and hence the optimal regulation is 0.*

(d) *For national and multinational firms, the optimal regulation is a continuous function of all parameters as long as no change of location is induced. As  $b \rightarrow \infty$ , the optimal regulation involves  $x_i = 0$ .*

We now ask to which extent the comparative analysis (Result 1) for the pure consumer surplus case generalizes.

**Proposition 5** *Suppose  $\gamma = 0$ .*

(a) *Fix  $a$ ,  $F$  and  $r_2$ .*

(i) *For every level of transportation costs, there exists a value of  $\bar{b}$  such that neither the national nor the multinational firm produces any output for  $b > \bar{b}$ .*

(ii) *If  $t$  is sufficiently small, but positive, there exists  $\underline{b} > 0$  such that both firms produce the same output level for  $b < \underline{b}$ .*

(b) *Fix  $a$  and  $F$ . Suppose  $r_2$  is sufficiently small. (i) If  $t$  is sufficiently small, there exist  $b_*$  and  $b^*$  such that  $b_* < b^*$  and multinational firms produce less home-country output than national firms for  $b \in (b_*, b^*)$ . (ii) If  $t$  is sufficiently large, there exist  $\tilde{b}$  such that multinational firms produce less home-country output than national firms for  $b < \tilde{b}$ .*

**Proof:** (a) (i) is just a restatement of Assumption 3(d): As  $b \rightarrow \infty$ ,  $r_i$  becomes so high for both firms that there is no output. (ii) First consider the multinational firm. Assume it has completely relocated. Fix  $t > 0$ , so that the output of the multinational firm is smaller than if there is no relocation by Assumption 2(biii) and hence complete relocation involves a loss in consumer surplus which is independent of  $b$ . By continuity of damages in  $b$  and in outputs (Assumption 3(d)), the damage reduction from relocation approaches 0 as  $b$  does. Thus, for every  $t > 0$  there is a critical value of  $b$  below which complete relocation is not optimal.

Moreover, for any given level of  $a$ ,  $F$  and  $r_2$ , if  $b$  is sufficiently small, the environmental gains from regulation are small by Assumption 3(c). By Assumption 2(b) and 3(b), the costs of regulation in terms of reduced consumer

surplus are positive and independent of  $t$ . Hence  $r_1$  becomes arbitrarily small as  $b$  does. If  $t$  is also sufficiently small, the multinational firm's gains from reduced transportation costs and regulation under partial relocation are small by continuity of profits in  $r_i$  and  $t$  (Assumption 2(d)), so that partial relocation is not worthwhile (due to the fixed, positive relocation costs involved). Thus, there is no relocation.

For the national firm, for sufficiently small  $b$ ,  $r_i$  also becomes arbitrarily small. By Assumption 2(f), home-country profits are positive. If  $t$  is also sufficiently small, continuity of profits (Assumption 2(d)) and symmetry (Assumption 2(c)) imply that it is worthwhile to serve the foreign market as well. Thus, both firms are serving both markets and face the same regulation to which they react in the same way.

(b) (i) Fix all parameters except  $b$ . By Assumption 3(d), regulation optimally reduces outputs to zero as  $b \rightarrow \infty$ . For  $b = 0$ , there is no regulation and the firm has a positive home country output by Assumption 2(f). By continuity of optimal regulation in  $b$  and continuity of outputs in  $r_i$ , the intermediate value theorem implies that there exists a minimal  $\bar{b} \geq 0$  such that the production of the national firm is optimally reduced to 0. By continuity of  $x_{ji}$  the optimal regulation of the multinational firm at  $\bar{b}$  involves complete relocation with positive imports of country  $i$  if  $t$  and  $r_j$  are sufficiently small: While the advantage from reducing pollution by constraining either firm to producing for the home country is the same, the multinational firm still generates a positive consumer surplus whereas the national firm does not.

(ii) Let  $b$  be sufficiently small. By continuity of damages in outputs and  $b$ , the benefits from regulation become arbitrarily small. Therefore the optimal regulation level  $r_1$  is small for both the national and the multinational firm. According to Assumption 2(e), for any  $r_1$  there exists a critical value of  $t$  such that there is partial relocation of the multinational above this critical level. The regulation of the national firm is also close to zero. However, the multinational firm produces for both countries. Because outputs are continuous in regulation levels, the multinational firm produces less than the national firm.

Result a) identifies the conditions under which both firms are regulated so that they choose the same output levels. In qualitative terms, the regions where this is the case correspond to those shaded grey in Figure 2. Result b) uncovers the two forces because of which the multinational firm might produce less than the national firm: Result (i) reflects the intuition that for low transportation costs and intermediate values of damages, regulators want to close down home production of the multinational firm, because supply from abroad is not costly. Result (ii) reflects the effect that for large transporta-



tion costs and low damages multinational firms will not produce in the home country whereas national firms still do.

However, note that we have not included a generalization of the result that, for large transportation costs and intermediate values of the damage parameter, the multinational firm produces more output. While the logic of the result in Section 6 that multinational firms pollute more than national firms for some parameter regions is quite general, it merely implies that, *if* there are some points in the partial relocation regime where it is optimal to prevent exports of the national firm, then the multinational firm will be regulated less for these values and produce larger outputs. While there are large parameter regions where this logic is confirmed, there are also parameter regions where this is not the case.

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