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Environmental policy diffusion and lobbying

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Abstract

In this article, we examine the regulation of pollution in an open economy when the regulator is influenced by special interest groups. Using a political contest framework, we aim to explain policy diffusion, i.e., a country adopting environmental policies similar to the stricter regulatory standards of its trading partners. In our model, two lobby groups—representing industrial and environmental special interests—influence their government’s policy decision. Their lobbying efforts not only depend on the domestic policy, but also on environmental regulation abroad. We develop a general framework to identify conditions under which a country may unilaterally adopt stricter regulatory standards and—using common functional forms to specify our model—we show that both market structure and the characteristics of the pollutant are crucial determinants of the political equilibrium.

Keywords: environmental regulation, policy diffusion, California effect, lobbying, contests

1 Introduction

A common observation over the last decades was the diffusion of environmental policies among separate jurisdictions and governance structures: when a legislator implements environmental regulation, other states/countries often implement similar policies. This was indeed true for the case of vehicle emission standards: as early as the 1959, California began regulating motor vehicle emissions. In 1970, it was granted permission to exceed the federal standards while all other states could choose whether to enact federal or California’s emission regulation. Not only did more and more US states follow California’s example, in the

1970s Japan and the European Community also adopted identical policies as did South Korea in the 1980s (see Vogel, 1997a; Biedenkopf, 2012a). This kind of regulatory convergence is typically referred to as ‘policy diffusion’, i.e., the decentralized dissemination of stricter regulation to other countries (or states).¹ To explain the existence of such policy diffusion, a number of reasons have been asserted. First, countries may adopt similar regulations due to coercion or emulation. Second, countries may observe successful foreign regulation and decide to implement such policies domestically. Third, there may exist competition among countries, which provides an incentive to implement (or retract) regulation. Although these explanations provide some understanding of what can drive policy diffusion, they largely neglect the important political aspect of the legislative process (see Biedenkopf, 2015). How do special interest groups impact regulation and, hence, the likelihood of policy diffusion? And what drives the lobbying efforts of the stakeholders?

In answering these questions, our focus is on unilateral policy decisions. In order to understand the role of special interest groups in the diffusion of policy, we develop a political economy model in which a regulator—under the influence of political activity—unilaterally sets its environmental policy. Our contest framework allows us to identify conditions for successful policy diffusion. We assume that environmental regulation exists in a foreign country but not domestically. Within the domestic country, the regulator proposes environmental regulation and special interest groups then invest effort in order to approve or reject the proposed policy. Whether or not the proposed regulation is implemented, in which case policy diffusion occurs, crucially hinges on the domestic lobby groups: given the respective efforts of the interest groups, the policy proposal is either approved or rejected by the legislator. The pivotal role assigned to special interest groups in our model is common to most parliamentary systems, where lobbyists often have a considerable impact on the legislative process. This is, for example, the case in the US legislator, where interest groups have direct and transparent access to Congressmen/Senators. Our model, therefore, duly accounts for the political contest that typically precedes the implementation of virtually any regulatory measure in most democratic systems.

Our political economy framework enables us to identify conditions under which—even

¹The literature occasionally also refers to a country adopting stricter regulation from its trading partners as ‘California effect’ (Vogel, 1997a; Fredriksson and Millimet, 2002a,b). See discussion below.

without international coordination—competing countries may independently adopt stricter regulatory standards, i.e., it helps to understand the different drivers of policy diffusion. We show that, as one would expect, the relative stringency of regulation in the two countries plays an important role. In fact, it is the elasticity of the interest groups' efforts with respect to these policy levels that crucially determines the political equilibrium. We highlight that, contrary to conventional rationale, a stricter policy proposal may reduce the opposition from the industrial lobby group. Although stricter regulation increases marginal production costs, a supply side effect, it can also increase the price of the good and thus marginal revenue, a demand side effect. If the latter outweighs the former, we show that an increase in the stringency of the proposed policy increases its chances of implementation. Similarly, we identify the elasticity of the interest groups' efforts with respect to the foreign environmental policy level as key driver of the political process. The elasticity of the groups' efforts are driven by the impact of regulation on profit and environmental damage, respectively, and, therefore, depend on the output produced domestically. As a result, we identify the shape of the environmental damage function as well as the relative slopes of demand and supply curves, which determine the market equilibrium, as pivotal factors in determining whether or not policy diffusion occurs. We demonstrate these results using different functional specifications and extend our basic framework with perfect competition to the cases of Stackelberg and Cournot competition.

To model the political economy of the legislator, we draw on the theory of contests (summarized by Konrad, 2009). The policy proposal by the domestic regulator defines what is at stake for the industrial and environmental special interest groups: if implemented, stricter regulation of pollution increases production costs and typically decreases profits whereas it also reduces the damage from pollution. Hence, the industrial lobby group usually opposes the introduction of such a policy while the environmental lobby group supports it, i.e., they expend effort in order to increase the chances of their favored policy being passed (or kept). More specifically, based on the notion that lobbies can influence yet not dictate a policy decision, the lobbying efforts define the probability of the policy proposal being implemented (see, e.g., Tullock, 1980; Epstein and Nitzan, 2010). As such, our contest model determines the probability of policy diffusion given political influence and we analyze the conditions that increase (or decrease) this probability. Indeed, despite the fact that the industry typically tries to hinder the implementation of regulation, we frequently observe diffusion of environmental

policies. This can be the case even if countries do not cooperate and such policies affect the competitive (dis-)advantage of a country's producers. Recent examples of such regulatory convergence are China's regulation of hazardous substances in electronics, which closely mirrors the EU's RoHS directive as well as policies adopted by South Korea in 2011 to regulate chemicals in a way that was widely based on the EU's REACH directive (see Biedenkopf, 2012b, 2013).² Although other causes could underlie the policy convergence in these particular cases, our model offers an important explanation: if the environmental lobby reacts relatively stronger to a proposed change in regulation than the industry, the probability of policy diffusion increases. This is often caused by a change in foreign regulation: if the foreign country tightens its regulation, production typically shifts to the domestic industry, which increases local pollution and, hence, the efforts of the domestic environmental lobby. According to our model, the introduction of, for example, South Korea's regulation of chemicals could thus be (partly) explained by the introduction of more stringent policies in the EU shortly before and the production shift that ensued (or the threat thereof).

The comparative politics literature on policy diffusion has identified a considerable number of such examples of regulatory convergence from eco-labeling to the promotion of renewable energy (see, e.g., Busch and Jörgens, 2005; Busch et al., 2005). These studies have also identified some of the major processes through which the strict policies of pioneer countries diffuse to other countries. Learning from the experience of others is an important factor and such learning can be facilitated through international institutions that provide the framework for sharing best practices (see Oberthür and Tänzler, 2001). Countries may also adopt similar policies due to emulation or coercion. These policies may be part of (trade) sanctions or conditions required for cooperation. For example, membership in the EU or WTO require a large degree of harmonization of the regulatory framework. Finally, Biedenkopf (2015) as well as Busch et al. (2005) highlight competition as a potential cause for diffusion: while economic competition can cause pressure to retract regulation, they also identify the integrated global market as a source for convergence towards stricter policies. If firms have to comply with regulatory standards in one market, they may find it easier to comply with these standards in all markets. This, of course, would reduce the political opposition to regulation in the latter.

²RoHS: Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment; REACH: Council Regulation (EC) No 1354/2007 on the Registration, Evaluation, Authorisation and Restriction of Chemicals

Such political aspects of policy diffusion, however, have not been studied (see Biedenkopf, 2015). We use a political economy model to fill this void and are able to add another possible explanation for policy diffusion, namely the pressure by special interest groups.

Initially, the conventional intuition in the economics literature was that regulatory competition between freely trading countries (jurisdictions) would lead to a policy race to the bottom as regulators would compete for mobile resources and would try to improve their respective industry's positioning on the global market (see, among others, Pethig, 1976; Brander and Spencer, 1985; Levinson, 1996; Rauscher, 2001). More recently, Vogel (1997a,b) and Kahn (1996), in particular, found evidence for the opposite effect: in what is sometimes referred to as race to the top, jurisdictions unilaterally adopted the stricter standards of other states/countries, a situation that can be compared to policy diffusion. In two studies, Fredriksson and Millimet (2002a,b) analyze this so-called 'California effect' empirically. While they cannot validate California's apparent leadership role, they do find some support for the conjecture that jurisdictions may follow the lead of environmentally stringent states. We do not attempt to settle the debate on the direction of policy races—in fact, we do not consider the repeated interaction underlying such a race—yet we aim to develop a framework that enables us to identify conditions under which policy diffusion appears more (less) likely in political equilibrium.

Note that studies on policy races are closely related to the literature on environmental federalism, which seeks to answer the question how to optimally share the responsibility of regulating pollution across different levels of government (see, e.g., Oates, 2001; Revesz, 2001; Kuncze and Shogren, 2005). To analyze this issue, the response of one jurisdiction to regulatory changes in another is, of course, of crucial importance. In addressing this strategic interaction, however, studies on environmental federalism have paid little attention to how industrial and environmental lobby groups shape this response, an aspect that is vital to our analysis.

Numerous studies on the political economy of trade and the environment have highlighted the important impact of lobby groups on the interplay between trade and environmental policies. This literature has, however, mostly focused on issues such as instrument choice and the optimal balance between trade and environmental regulation following trade liberalization, which we abstract from (see Sturm, 2003, for a survey). Our focus, on the other hand, is on the strategic interaction between opposing lobby groups and on the important effect of foreign

regulation on their respective lobbying incentives, two aspects that few of these studies have considered. In fact, to the best of our knowledge, this paper is the first to analyze the political activity that can drive the diffusion of environmental policies in open economies. Although Fredriksson (1997) starts with assumptions similar to ours in his analysis of pollution taxes in a small open economy, his focus is on the regulatory framework in one country only without accounting for the competitive (dis-)advantage caused by stricter (weaker) policies abroad, which is pivotal to our understanding. Conconi (2003), who analyzes regulation in two countries in a Grossman and Helpman (1994) framework, studies cooperative and non-cooperative policies as well as the comparison between free and restricted trade while acknowledging the role of regulation in the other country. She concludes that policy coordination is more important with free trade. Yet we are able to show that even with free trade, unilateral regulation may suffice to lead to policy convergence in political equilibrium.

Our contribution, therefore, is the first analysis of policy diffusion when the political economy of the legislator is taken into account. The political science literature, in particular, has offered a number of potential explanations for policy diffusion including cooperation and emulation. We abstract from these causes and explain how policy diffusion can occur even if countries act unilaterally. To do so, we account for the important, yet previously neglected role of interest groups in the regulatory process and show that political influence can offer yet another potential explanation for the convergence of environmental regulation.

The paper is organized as follows. In Section 2, we develop our general model with two countries, where regulation is in place in the foreign country while two opposing lobby groups in the home country try to facilitate/hinder the implementation of regulation. The industries of the two countries compete on a global output market. We derive the equilibrium and some general results. In section 3, introducing fairly common assumptions regarding the shape of the demand, supply, and damage functions, we demonstrate the applicability of our general framework using two different specifications of our model—a linear as well as a non-linear example—to derive explicit results and to identify the drivers of policy diffusion. While our focus is on perfect competition, Section 4 extends our model to Cournot and Stackelberg competition and highlights the differences. Section 5 allows for heterogeneous production technologies and Section 6 concludes.

2 The model

2.1 Model setup

Consider a set of countries $J = \{h, a\}$ (home and abroad) that produce a homogeneous good for a (global) market.³ Within country $j \in J$ production is provided by a representative firm: firm j in country j can sell its production x_j (either domestically or internationally) at a world price p_w .⁴ The world price is determined by the inverse global demand function $p_w(X)$, which is strictly decreasing and quasi-concave in total production, where $X \equiv x_j + x_{-j}$ and $-j \in J \setminus \{j\}$. Note that in a perfectly competitive market, production from firm j may be negligible compared to global output X , thus not affecting the world price. We assume production of x_j generates local pollution: damages associated with pollution from firm j are only experienced in country j . To control local pollution, the government in country j can introduce pollution regulation. The stringency of environmental regulation is captured by parameter $\tau_j \in [0, \infty)$. If $\tau_j > 0$, then environmental regulation reduces emissions (and environmental stringency is increasing in τ_j). Our focus is on the policy choice in country h and we assume that foreign environmental regulation has been adopted at some level $\tau_a > 0$. In the home country, the status quo is a situation where no regulation exists, i.e., $\tau_h = 0$. Let $\tilde{\tau}_h$ denote the government's proposed environmental regulation in country h .⁵ Thus the government's policy options are $\tau_h \in \{0, \tilde{\tau}_h\}$.

Once an initial regulatory standard has been proposed, special interest groups lobby the government in an effort to influence the probability of legislative approval. This mimics many aspects of lobbying activity within parliamentary systems. For example, once a bill enters a debating chamber, lobbyists often have significant influence over the probability of the bill passing.⁶ Denote the set of special interest groups as $L = \{B, G\}$. The brown (B) lobby, which

³Our model is easily replicated with a set $|J| = n > 2$; however, with very large n , the marginal impact of any one country's policy on the regulatory choice of other countries converges to zero, which might be too restrictive for the description of real politics. The limitation to two countries, on the other hand, may be well-founded in the real world: country a may represent the rest of the world in a competitive market or countries h and a may represent two major producers of the product in question. In the latter case, our framework could thus model, for example, the impact of stricter pollution control in the EU on environmental regulation in the US.

⁴Note that we assume free trade, i.e., we abstract from complementary trade policies such as border tax adjustments that would result in country-specific prices.

⁵Note that $\tilde{\tau}_h$ can be proposed at any level, including a level corresponding to the exact stringency of τ_a or it could be derived from an optimization by the regulator. In the latter case, the objective function of the regulator would have to be defined.

⁶In principle, the interest groups could also compete over the level of a continuous policy parameter τ_h . Yet, a parliamentary discussion over a single bill is more realistic and adds to the ease of interpretation of our results.

represents the interests of the domestic firm, typically tries to prevent more stringent regulation, whereas the green (G) lobby—representing environmentalists in the home country—supports the new policy proposal. We model the approval or non-approval of the proposed policy, as a contest, which determines the probability of the government’s proposal being implemented. The timing of our model is as follows: the government in country h proposes an initial level of environmental regulation $\tilde{\tau}_h$. Special interest groups then invest in lobbying effort in order to alter the probability of policy approval. Next, knowing the current regulatory levels at home and abroad, firm h competes on the global product market and payoffs for both lobbies ensue. We proceed with our analysis using backward induction, first deriving the market equilibrium for any given level of τ_h . This allows us to define the political stakes of the lobby groups, which we then use to derive the probability of a policy proposal being implemented.

2.2 The market equilibrium

In the previous stage, the policy level $\tau_h \in \{0, \tilde{\tau}_h\}$ has been determined via the political process. Thus for given policy levels τ_h and τ_a , the representative firm j selects output that maximizes profit:

$$\max_{x_j} \pi_j(x_j(\tau_j, \tau_{-j}), \tau_j) = x_j(\tau_j, \tau_{-j}) \cdot p_w(X(\tau_j, \tau_{-j})) - c_j(x_j(\tau_j, \tau_{-j}), \tau_j). \quad (1)$$

The profit of firm j is a function of the production level and the stringency of (domestic and foreign) regulation. For firm j ’s production cost we assume $\frac{\partial c_j}{\partial x_j} > 0$ and $\frac{\partial c_j}{\partial \tau_j} > 0$ and consider positive levels of production within country j , such that $\frac{\partial c_j(0)}{\partial \tau_j} < p_w(0)$ for all levels of τ_j . Given that firms may pass (part of) the additional cost of regulation on to their customers, we assume $\frac{\partial p_w}{\partial \tau_j} \geq 0$ and $\frac{\partial p_w}{\partial \tau_{-j}} \geq 0$. Domestic production is inversely related to the level of regulation, i.e., $\frac{\partial x_j}{\partial \tau_j} < 0$, whereas stricter foreign regulation increases the domestic firm’s share of the global market and hence, $\frac{\partial x_j}{\partial \tau_{-j}} > 0$. Both domestic as well as foreign regulation are important factors for the domestic firm’s choice of production x_j : stricter foreign regulation can affect firm j ’s profit positively in two ways as it (i) can increase the price of the product and (ii) increases the amount produced in country j .

The latter, however, also has harmful effects in country j . As stricter foreign regulation in-

creases domestic production, consequently, it also increases the amount of local pollution and the ensuing environmental damage. We denote environmental damage by $D_j(x_j(\tau_j, \tau_{-j}), \tau_j)$, which is decreasing in the policy level but increasing in the production level; i.e., $\frac{\partial D_j}{\partial \tau_j} < 0$, $\frac{\partial D_j}{\partial x_j} > 0$ and $\frac{\partial^2 D_j}{\partial x_j^2} \geq 0$.

2.3 The political equilibrium

Without loss of generality, let us focus on country h , the home country. Our main aim in this article is to investigate policy diffusion between countries, i.e., how environmental regulation of (local) pollution in a foreign country (or a group of foreign countries) affects environmental regulation domestically. To begin the analysis, we suppose that foreign regulation was set at a level $\tau_a > 0$. Thus, given the existence of stringent foreign environmental policy, we want to investigate the consequences for regulation in the domestic country.

We denote by Γ^τ (Γ^0) and Π^τ (Π^0) the payoff of the green and brown lobby groups, respectively, if (no) environmental regulation is introduced.⁷ More specifically, the green lobby's payoff under regulation is given by

$$\Gamma^\tau = -D_h(x_h(\tilde{\tau}_h, \tau_a), \tilde{\tau}_h) \equiv -D_h(x_h^\tau, \tilde{\tau}_h), \quad (2)$$

whereas, if no regulation is approved, the green lobby experiences losses from environmental damage and its payoff is:

$$\Gamma^0 = -D_h(x_h(0, \tau_a), 0) \equiv -D_h(x_h^0, 0). \quad (3)$$

The green lobby's relative stake in the lobbying process is thus

$$V_G = \Gamma^\tau - \Gamma^0 > 0. \quad (4)$$

Unsurprisingly, the green lobby prefers more stringent regulation. The brown lobby on the

⁷Given our focus on country h and the fact that the optimization problem for the lobby groups in both countries is analogous, for brevity of notation, we omit a subscript for countries h and a whenever it is unambiguous to do so.

other hand typically prefers no regulation, which results in

$$V_B = \Pi^0 - \Pi^\tau > 0, \quad (5)$$

where

$$\Pi^0 = \pi_h(x_h(0, \tau_a), 0) \equiv \pi_h(x_h^0, 0) \text{ and} \quad (6)$$

$$\Pi^\tau = \pi_h(x_h(\tilde{\tau}_h, \tau_a), \tilde{\tau}_h) \equiv \pi_h(x_h^\tau, \tilde{\tau}_h). \quad (7)$$

We present the lobbying process as a contest in which lobby groups invest sunk efforts to influence the probability of legislative policy approval. In particular, denote k_l as the effort lobby group l expends in order to support or fight the proposed policy. The respective probabilities for the green and brown lobby to be successful are dependent on their lobbying efforts relative to total outlays and given by:

$$\rho_l(k_l, k_{-l}) = \begin{cases} \frac{k_l}{k_l + k_{-l}} & \text{if } \max\{k_l, k_{-l}\} > 0, \\ \frac{1}{2} & \text{otherwise,} \end{cases} \quad (8)$$

where $-l = L \setminus \{l\}$.⁸ For ease of notation, we denote $\rho_G = \rho$ and $\rho_B = 1 - \rho$. The probability of the proposed regulation $\tilde{\tau}_h$ being approved is equivalent to the probability of success of the green lobby, $\rho = \frac{k_G}{k_G + k_B}$. Using (2), (3), (6), and (7), the lobbyists maximize their respective net expected payoffs given by

$$\max_{k_G} E[\Gamma] = \rho \cdot \Gamma^\tau + (1 - \rho) \cdot \Gamma^0 - k_G,$$

$$\max_{k_B} E[\Pi] = (1 - \rho) \cdot \Pi^0 + \rho \cdot \Pi^\tau - k_B.$$

The solution to this game is a pure strategy Nash equilibrium with equilibrium effort levels given by

$$k_l^* = \frac{V_l^2 \cdot V_{-l}}{(V_l + V_{-l})^2}.$$

⁸See Epstein and Nitzan (2010) for an extensive analysis of this mechanism.

where V_l is determined in (4) and (5), which are the relative stakes in the political contest for each special interest group. We can rewrite the equilibrium probability of policy diffusion, i.e., the successful implementation of regulation in the home country, as

$$\rho^* = \frac{V_G}{V_G + V_B}, \quad (9)$$

which is the green lobby group's political stake relative to total political stakes.

The aim of this article is to investigate policy diffusion: how stringent foreign regulation can alter the probability of domestic regulation. Our primary interest is thus in how ρ^* is influenced by foreign regulation, yet we are also interested in how the level of the proposed policy affects the political equilibrium.

2.4 Domestic regulatory influence on the political equilibrium

We, therefore, now turn to investigate the effects of domestic regulation on the political equilibrium, and, in particular, how the stringency of domestic regulation alters the equilibrium probability of legislative approval, ρ^* . The latter, of course, hinges on the green lobby's efforts and thus their stake in the contest, which, in turn, depends on the level of the proposed policy. To analyze how the equilibrium outcome is affected by the level of the (proposed) environmental policy, we first need to determine how the stakes of the special interest groups are impacted. Using (4) and (5), it follows that:

$$\frac{\partial V_G}{\partial \tilde{\tau}_h} = \underbrace{-\frac{\partial D_h(x_h^\tau, \tilde{\tau}_h)}{\partial x_h^\tau}}_{>0} \cdot \underbrace{\frac{\partial x_h^\tau}{\partial \tilde{\tau}_h}}_{>0} - \underbrace{\frac{\partial D_h(x_h^\tau, \tilde{\tau}_h)}{\partial \tilde{\tau}_h}}_{>0} > 0, \text{ and} \quad (10)$$

$$\frac{\partial V_B}{\partial \tilde{\tau}_h} = -\left(\frac{\partial x_h^\tau}{\partial \tilde{\tau}_h} \cdot p_w^\tau + \frac{\partial p_w^\tau}{\partial X^\tau} \cdot \frac{\partial X^\tau}{\partial \tilde{\tau}_h} \cdot x_h^\tau\right) + \frac{\partial c_h^\tau}{\partial x_h^\tau} \cdot \frac{\partial x_h^\tau}{\partial \tilde{\tau}_h} + \frac{\partial c_h^\tau}{\partial \tilde{\tau}_h} = \underbrace{-\frac{\partial p_w^\tau}{\partial \tilde{\tau}_h} \cdot x_h^\tau}_{<0} + \underbrace{\frac{\partial c_h^\tau}{\partial \tilde{\tau}_h}}_{>0} \geq 0, \quad (11)$$

where $c_h^\tau \equiv c_h(x_h^\tau, \tilde{\tau}_h)$, $p_w^\tau \equiv p_w(X^\tau)$, where $X^\tau \equiv x_h^\tau + x_a^\tau$, and $x_a^\tau \equiv x_a(\tilde{\tau}_h, \tau_a)$.

The stakes of the green lobby strictly increase in the level of the proposed policy. This has to be expected as a higher policy level directly decreases environmental damage from production and reduces domestic output. Hence, it is in the interest of the green lobby. More surprisingly, however, the stakes of the brown lobby may increase or decrease given a change in the suggested policy. This is due to the fact that, on the one hand, a stricter environ-

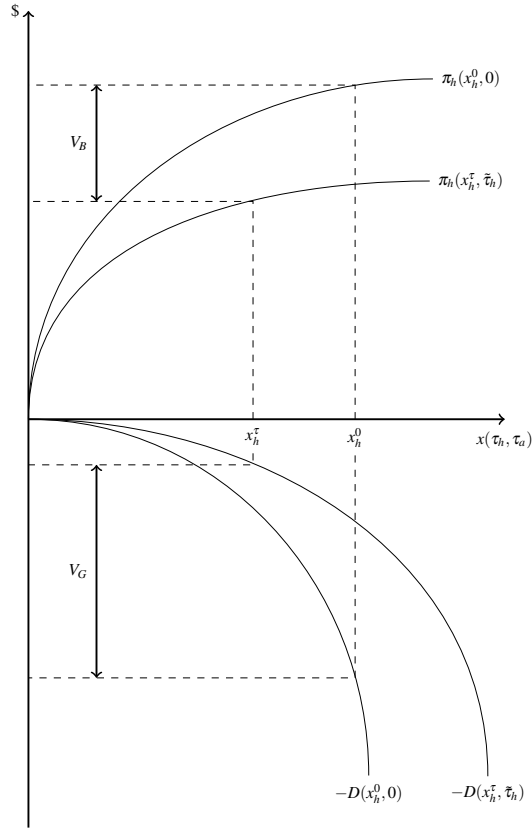


Figure 1: The lobbies' stakes as a function of equilibrium output in country h .

mental policy increases production costs—as represented by the second term in (11)—thereby increasing the stakes of the brown lobby. On the other hand, however, stricter regulation can increase the product price and raise marginal revenue—as reflected in the first term in (11)—which lowers the stake of the industry lobby.⁹ Whether the former effect (the *supply side effect*) dominates the latter effect (the *demand side effect*) is, *a priori*, unclear. If marginal production costs are increasing, however, it can be expected that the supply side effect typically prevails, in which case a marginal increase in $\tilde{\tau}_h$ unambiguously raises the stake of the industry as the industry then faces the risk of a higher foregone profit if the policy is implemented.

The relationship between the stakes of the lobbies and the proposed policy levels is illustrated in Figure 1, where a marginal increase of $\tilde{\tau}_h$ (if implemented) would reduce domestic equilibrium production x_h^τ , which—for this particular case—leads to an increase of both V_B and V_G . Ultimately, however, we are interested in the impact of a marginal increase in $\tilde{\tau}_h$ on the probability of this policy proposal being implemented, which is determined by

⁹Note that marginal revenue can only increase if country h has market power and $\frac{\partial p_h^\tau}{\partial \tilde{\tau}_h} > 0$. If there is perfect competition, $\frac{\partial V_B}{\partial \tilde{\tau}_h} > 0$.

$$\frac{\partial \rho^*}{\partial \tilde{\tau}_h} = \frac{\frac{\partial V_G}{\partial \tilde{\tau}_h} V_B - \frac{\partial V_B}{\partial \tilde{\tau}_h} V_G}{(V_B + V_G)^2}.$$

Although one may intuitively expect a marginal increase in the proposed policy level $\tilde{\tau}_h$ to decrease the probability of it being implemented, this need not be the case. In fact, as the above derivative shows, the probability of policy implementation is strictly increasing if, for the brown lobby, the demand side effect outweighs the supply side effect. Proposition 1 directly follows:

Proposition 1. *The equilibrium probability of policy diffusion, ρ^* , increases in the stringency of the proposed environmental regulation if*

$$\frac{\frac{\partial V_G}{\partial \tilde{\tau}_h}}{V_G} > \frac{\frac{\partial V_B}{\partial \tilde{\tau}_h}}{V_B}. \quad (12)$$

Proposition 1 establishes the condition required so that the probability of policy diffusion increases with respect to domestic regulation. Relative to the original levels, this occurs as long as the change of the green lobby's stake is greater than the shift of the brown lobby's stake. In other words, for ρ^* to be increasing in $\tilde{\tau}_h$, the elasticity of the green lobby's stake with respect to the policy variable has to be greater than the elasticity of the brown lobby's stake. Note that this result does not depend on any particular functional specification nor on the type of the pollutant. As we show in section 3, these factors are, however, crucial in determining whether or not condition (12) actually holds.

2.5 Foreign regulatory influence on the political equilibrium

We now turn to investigate how foreign regulation alters the domestic political equilibrium. It is important to note that the efforts of both special interest groups are affected by foreign regulation. The brown lobby will alter lobbying efforts in relation to changes in their competitive advantage due to the adoption of foreign regulation. At the same time, foreign regulation can indirectly raise the stake of the green lobby as it shifts production to country h (equivalent to a shift of the equilibrium quantity x_h to the right in figure 1¹⁰). It is the effect from foreign regulation that we are most interested in as we try to explain if countries with relatively

¹⁰Note that while a marginal change in $\tilde{\tau}_h$ only results in a shift of x_h^τ , a marginal increase in τ_a shifts both x_h^τ and x_h^0 to the right.

strict environmental regulation can initiate similar policies elsewhere by setting an example for their competitors. In other words, the question we address is whether stricter levels of foreign regulation can increase the probability of policy diffusion.

Similar to Subsection 2.4, we analyze the impact of a change in foreign regulation on the probability of the proposed policy $\tilde{\tau}_h$ being passed. We find that the impact of a change in foreign policy, on the stakes of both lobby groups, is ambiguous:

$$\frac{\partial V_G}{\partial \tau_a} = \underbrace{-\frac{\partial D_h(x_h^\tau, \tilde{\tau}_h)}{\partial x_h^\tau}}_{<0} \cdot \frac{\partial x_h^\tau}{\partial \tau_a} + \underbrace{\frac{\partial D_h(x_h^0, 0)}{\partial x_h^0}}_{>0} \cdot \frac{\partial x_h^0}{\partial \tau_a} \geq 0, \quad (13)$$

$$\frac{\partial V_B}{\partial \tau_a} = \frac{\partial p_w^0}{\partial \tau_a} \cdot x_h^0 - \frac{\partial p_w^\tau}{\partial \tau_a} \cdot x_h^\tau \geq 0. \quad (14)$$

Note that foreign regulation τ_a has no direct effect on production costs nor on environmental damage. There is, however, an indirect quantity effect as production shifts to the domestic market. This is equivalent to the previously defined *demand side effect*. Thus the sign of $\frac{\partial V_B}{\partial \tau_a}$ depends on whether the *demand side effect* is greater for larger quantities of x_h (no regulation) or smaller quantities (with regulation). An important driver of the sign of either derivative is thus the elasticity of demand: (i) given that the environmental damage function is increasing, $\frac{\partial V_G}{\partial \tau_a}$ is typically positive and could only be negative if either the damage function were concave or if x_h^τ was more sensitive than x_h^0 (for an increase in τ_a); (ii) given $x_h^0 > x_h^\tau$, $\frac{\partial V_B}{\partial \tau_a} < 0$ only occurs if $\frac{\partial p_w^\tau}{\partial \tau_a}$ is sufficiently greater than $\frac{\partial p_w^0}{\partial \tau_a}$, i.e., if the product price is sufficiently sensitive to changes in τ_a at some level $\tilde{\tau}_h$.

Ultimately, we are interested in the sign of these derivatives mainly because we seek to analyze the impact of a change in τ_a on the probability of policy diffusion, i.e., successful regulation in the home country. The impact of τ_a is driven by the lobbies' stakes and characterized by the derivative

$$\frac{\partial \rho^*}{\partial \tau_a} = \frac{\frac{\partial V_G}{\partial \tau_a} V_B - \frac{\partial V_B}{\partial \tau_a} V_G}{(V_B + V_G)^2}$$

from which the following proposition directly follows:

Proposition 2. *The equilibrium probability of policy diffusion, ρ^* , is increasing in foreign regulatory stringency if*

$$\frac{\frac{\partial V_G}{\partial \tau_a}}{V_G} > \frac{\frac{\partial V_B}{\partial \tau_a}}{V_B}. \quad (15)$$

Proposition 2 again highlights the importance of the elasticities of the interest groups' political stakes with respect to a change in the policy parameter, here τ_a . For any functional specification, the probability of the proposed policy $\tilde{\tau}_h$ being implemented is increasing in τ_a only if the relative reaction of the green lobby's political stake is stronger than that of the brown lobby's political stake.

3 Specifying the general model

In order to demonstrate the applicability of our results, we now specify the general functions of the previous section using fairly standard assumptions regarding the shape and characteristics of the demand, supply, and damage functions. Without loss of generality, we continue to focus on the effects of policy changes in home country h . We start our analysis assuming a perfectly competitive market such that global output is largely served by country a , which one may consider as representing the rest of the world. Domestic supply is determined by marginal production cost, which is easily derived from

$$c_h(x_h(\tau_h, \tau_a), \tau_h) = \frac{1}{2} \cdot \sigma \cdot x_h(\tau_h, \tau_a)^2 + \tau_h \cdot x_h(\tau_h, \tau_a), \quad (16)$$

where $\sigma > 0$ is a cost parameter characterizing the production technology. Environmental regulation leads to an upward shift of the demand curve as it would, for example, be caused by the introduction of an environmental tax or the requirement of installing filter technology in the output (e.g., in cars). Focusing on the effect of differences in regulation, we assume that the production technology σ and, therefore, the cost structure, are the same in country a —an assumption we later relax—and that inverse demand is given by

$$p_w(X(\tau_h, \tau_a)) = A - \alpha \cdot X(\tau_h, \tau_a), \quad (17)$$

where $A > 0$ and $\alpha > 0$ are parameters characterizing global demand. With perfect competition, firm h contributes a negligible amount to the global output X and, therefore, faces an exogenous world price $p_w(x_a)$. Equilibrium production levels and world price are then given

by

$$x_a^* = \frac{A - \tau_a}{\alpha + \sigma}, \quad (18)$$

$$x_h^* = \frac{\sigma A + \alpha \tau_a - \tau_h(\alpha + \sigma)}{\sigma(\alpha + \sigma)}, \quad (19)$$

$$p_w^* = \frac{\sigma A + \alpha \tau_a}{\alpha + \sigma}, \quad (20)$$

where $\tau_h \in \{0, \tilde{\tau}_h\}$. Given equilibrium price and quantities, the following equations summarize the profit of the representative firm depending on whether or not the proposed policy level $\tilde{\tau}_h$ is implemented:

$$\begin{aligned} \Pi^0 &= \frac{(\sigma A + \alpha \tau_a)^2}{2\sigma(\alpha + \sigma)^2}, \\ \Pi^\tau &= \frac{(\sigma A + \alpha \tau_a - \tilde{\tau}_h(\alpha + \sigma))^2}{2\sigma(\alpha + \sigma)^2}. \end{aligned}$$

The difference between these potential payoffs defines the stake of the brown interest group within the political contest, which is thus given by

$$V_B = \frac{\tilde{\tau}_h(2(\sigma A + \alpha \tau_a) - \tilde{\tau}_h(\alpha + \sigma))}{2\sigma(\alpha + \sigma)}, \quad (21)$$

and which determines the effort that the industrial lobby expends in order to increase the probability of $\tilde{\tau}_h$ not being implemented. From Propositions 1 and 2 we know that the probability of policy diffusion is crucially driven by the reaction of the lobby groups to changes in regulation. By taking the derivatives of (21) with respect to $\tilde{\tau}_h$ and τ_a , we determine the impact of marginal changes in the policy levels on the political stake of the brown lobby. Our results are summarized in the following lemma:

Lemma 1. *Changes in the stringency of environmental regulation in countries h and a affect the stake of the brown interest group in country h as follows:*

$$\frac{\partial V_B}{\partial \tilde{\tau}_h} > 0 \text{ and} \quad (22)$$

$$\frac{\partial V_B}{\partial \tau_a} > 0. \quad (23)$$

Proof. The proof is straightforward and therefore omitted. \square

From Lemma 1 it follows that the effect of a policy change in either country on the brown lobby's stake is unambiguously positive. Our assumption of a perfectly competitive market, of course, excludes the possibility of an increase in firm h 's marginal revenue, therefore, the *supply side effect* following a change in the proposed domestic regulation unambiguously determines the sign of $\frac{\partial V_B}{\partial \tilde{\tau}_h}$ (see equation (11)).

Equally important for the political equilibrium is, of course, the stake of the green lobby and its reaction to policy changes, which is driven by the impact of pollution as determined by the environmental damage function. We assume the latter to be given by

$$D_h(x_h(\tau_h, \tau_a), \tau_h) = (\omega_h - \tau_h) \cdot x_h(\tau_h, \tau_a)^z, \quad (24)$$

where $\omega_h > 0$ is a parameter defining the level of environmental damage and may be country specific and $z \geq 1$ determines the convexity of the damage function. The introduction of an environmental policy $\tau_h > 0$ —for example, the mandatory installation of filter technology—reduces environmental damage. As highlighted before, the probability of policy diffusion is driven by the elasticities of the interest groups' political stakes with respect to changes in the policy parameters $\tilde{\tau}_h$ and τ_a . For the green lobby, this elasticity is largely determined by the severity of environmental damage and—by analyzing two cases, $z = 1$ and $z = 2$ —we show that the impact of pollution is a pivotal factor determining the political equilibrium.

3.1 A model with linear environmental damage ($z=1$)

We start with a linear specification of the environmental damage function in order to focus on the direction of the effects of marginal changes in the policy levels on the green lobby's stake as well as on the drivers of these effects. The next subsection then demonstrates the applicability of our framework to a non-linear specification of the environmental damage function. If environmental damage is given by equation (24) with $z = 1$, the following equations summarize the payoffs of the green interest group depending on whether or not the proposed policy

level $\tilde{\tau}_h$ is introduced:

$$\Gamma^0 = -\frac{\omega_h (\sigma A + \alpha \tau_a)}{\sigma(\alpha + \sigma)} \text{ and}$$

$$\Gamma^\tau = -\frac{(\omega_h - \tilde{\tau}_h) (\sigma A + \alpha \tau_a - \tilde{\tau}_h(\alpha + \sigma))}{\sigma(\alpha + \sigma)}.$$

The environmental lobby group thus has a stake within the political contest given by

$$V_G = \frac{\tilde{\tau}_h (\sigma A + \alpha \tau_a - \tilde{\tau}_h(\alpha + \sigma)) + \omega_h(\alpha + \sigma)}{\sigma(\alpha + \sigma)}, \quad (25)$$

which determines the effort it expends to increase the probability of $\tilde{\tau}_h$ being implemented by the regulator. Again, we take the derivatives with respect to the (proposed) policy levels in countries h and a to determine the impact on the political stake of the green lobby. This reaction—and that of the brown lobby—ultimately drives the probability of policy diffusion. The direction of these impacts is summarized in the following lemma:

Lemma 2. *Changes in the stringency of environmental regulation in countries h and a affect the stake of the green interest group in country h as follows:*

$$\frac{\partial V_G}{\partial \tilde{\tau}_h} > 0 \text{ and} \quad (26)$$

$$\frac{\partial V_G}{\partial \tau_a} > 0. \quad (27)$$

Proof. The proof is straightforward and therefore omitted. \square

From (26) and (27) it follows that the effect of a policy change—at home or abroad—on the political stake of the environmental lobby is positive, which confirms our findings of Section 2. Using inequalities (12) and (15), we can now analyze the conditions under which policy diffusion is likely to occur and determine the sign of $\frac{\partial \rho^*}{\partial \tilde{\tau}_h}$ and $\frac{\partial \rho^*}{\partial \tau_a}$. Our results are summarized in the following proposition.

Proposition 3. *The equilibrium probability of policy diffusion, ρ^* , changes with respect to the strin-*

gency of environmental regulation as follows:

$$\frac{\partial \rho^*}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{\tilde{\tau}_h - \tau_a}{A - \tilde{\tau}_h} < \frac{\sigma}{\alpha} < \frac{\omega_h - \tau_a}{A - \omega_h}, \\ < 0 & \text{if } \frac{\sigma}{\alpha} > \frac{\omega_h - \tau_a}{A - \omega_h}, \text{ and} \end{cases} \quad (28)$$

$$\frac{\partial \rho^*}{\partial \tau_a} < 0. \quad (29)$$

Proof. See Appendix A.

Proposition 3 not only identifies the relative slopes of demand and supply as important drivers of the political equilibrium, but it also highlights the unexpected effect of stricter regulation abroad: on the one hand, by condition (28), if foreign regulation is stricter than the policy proposal in the home country, the probability of policy implementation at home may increase in the proposed level $\tilde{\tau}_h$ because the first inequality always holds. On the other hand, stricter foreign regulation itself has a negative effect on the probability of policy diffusion: given a linear environmental damage function, the support by the green lobby for the policy proposal is too weak to lead to regulatory convergence. As demand shifts from country a to country h , the industry has more to lose from regulation and increases its opposition to $\tilde{\tau}_h$. From equation (23) we know that—in a competitive market—the driver of this opposition, the supply side effect, is strong and, in this case, suffices to reduce the probability of policy implementation ρ^* .

To conclude, when a country is small and its industry faces perfect competition, the impact of strict foreign regulation on domestic policy is at best indirectly positive: if foreign policy is sufficiently strict relative to the domestic regulation yet not too strict relative to local environmental damage, this positively affects the chances of a marginally stricter policy proposal being implemented (see (28)). The direct effect of stricter foreign regulation, however, is negative and reduces the probability of policy diffusion.

3.2 A model with quadratic environmental damage ($z=2$)

While a linear damage function appropriately reflects the environmental impacts of a wide variety of pollutants and allows us to analyze the major features of our model in a very tractable way, there are many pollutants for which, e.g., a quadratic damage function is more appropriate to model their adverse impacts. Our general model framework is easily able to

accomodate this and we show that the political equilibrium can be pronouncedly different if the damage function is convex. Consider now an environmental damage function specified by equation (24) with $z = 2$. This may, for example, be representative of a stock pollutant whose environmentally harmful impact increases more and more as more of it is emitted. In this setting, the stake of the green lobby in country h is now given by

$$V_G^Q = \frac{(\tau_h - \omega_h)(\sigma A + \alpha\tau_a - \tau_h(\alpha + \sigma))^2 + \omega_h(\sigma A + \alpha\tau_a)^2}{\sigma^2(2\alpha + \sigma)^2}. \quad (30)$$

In combination with V_B (see (21)), V_G^Q defines the equilibrium probability of policy implementation in the home country (policy diffusion) denoted ρ^Q . To understand how changes in the policy levels at home or abroad affect ρ^Q , we analyze how such changes impact the stakes of the lobbies. The effect of policy changes on the stake of the green lobby, V_G^Q , is now summarized in the following lemma:¹¹

Lemma 3. *A change in the stringency of domestic (foreign) environmental regulation affects the stake of the green interest group in country h as follows:*

$$\frac{\partial V_G^Q}{\partial \bar{\tau}_h} > 0 \text{ and} \quad (31)$$

$$\frac{\partial V_G^Q}{\partial \tau_a} > 0. \quad (32)$$

Proof. The proof is straightforward and therefore omitted. \square

As in the case of linear environmental damage, the effect of a change in domestic (foreign) environmental regulation on the stake of the green lobby is unambiguously positive. The impact of policy changes on the probability of policy diffusion, however, differs as we show in the following proposition:

Proposition 4. *When environmental damage is defined by equation (24) with $z = 2$, the equilibrium probability of policy diffusion, ρ^Q , is affected by policy changes at home or abroad as follows:*

$$\frac{\partial \rho^Q}{\partial \bar{\tau}_h} < 0 \text{ and} \quad (33)$$

$$\frac{\partial \rho^Q}{\partial \tau_a} > 0. \quad (34)$$

¹¹The stake of the brown lobby is unchanged, hence, our results summarized in (22) and (23) remain valid.

Proof. The proof is straightforward and therefore omitted. □

Unlike in the linear case, the impacts of policy change at home or abroad are now both unambiguous, yet the direction of the effect of regulatory change abroad is inverted. Our results highlight the crucial role of the damage function as well as the importance of the slopes of the demand and supply curves: when environmental damage was defined by equation (24) with $z = 1$, a low level of domestic output and a relatively steep demand curve (compared to the supply curve, see (28)) allowed for a parameter range in which a stricter policy proposal by the regulator increased the chance of policy diffusion: for a small production level, the constant per unit reduction of pollution weighed stronger than the foregone profit, because the inelastic demand reduced the burden of stricter regulation for the firm. For higher levels of production, however, this effect was reversed. Given the newly specified, quadratic damage function, the political stake of the green lobby is greater, yet the marginal effect of a regulatory change on V_G is now smaller for low levels of output. As a result, the marginal impact of a (proposed) domestic policy change on the stake of the brown lobby is now stronger than that on the green lobby for any production level. Therefore, a stricter policy proposal unambiguously decreases the probability of policy diffusion. The effect is the opposite for a change in regulation abroad: the latter results in a shift of production from abroad to the home country, leading to higher profits for the domestic firm. In the linear case of the previous subsection, this effect was stronger than the marginal effect on pollution, which defines the green lobby's stake. With a quadratic damage function, however, the shift of production has a strong impact on pollution and the opposition of the green lobby increases sufficiently to always increase the probability of policy diffusion.

4 Oligopolistic competition

Thus far we have assumed a competitive product market. While for many industries this view seems reasonable given that we assume international markets, for other commodities it is plausible that the polluting industries are highly concentrated. In this section, using similar functional specifications as before, we analyze cases of imperfect competition when the competing industries are able to affect the world market price and $\frac{\partial p_w}{\partial \tau_j} > 0$. Global supply

is then determined by the horizontal aggregation of the supply by each country, which yields

$$C' = \frac{1}{2} (\sigma \cdot X(\tau_h, \tau_a) + \tau_h + \tau_a) \quad (35)$$

While we first deal with standard Cournot competition in which industries in both countries choose their quantity strategically but simultaneously, we also analyze Stackelberg competition, i.e., strategic quantity choice with a leader and a follower. As before, we demonstrate the importance of the damage function by analyzing both the linear as well as the quadratic cases. Given that the major results from our general model still hold, we simply report results and highlight differences.

4.1 Simultaneous quantity choice and linear environmental damage

With the industries deciding on their quantities strategically, their objective functions change and now account for their impact on the world market price. Yet we find that marginal changes in either domestic or foreign regulatory stringency continue to unambiguously increase the stakes of both lobby groups, i.e., $\frac{\partial V_B^C}{\partial \tilde{\tau}_h} > 0$, $\frac{\partial V_G^C}{\partial \tau_a} > 0$, $\frac{\partial V_G^C}{\partial \tilde{\tau}_h} > 0$, and $\frac{\partial V_G^C}{\partial \tau_a} > 0$. Furthermore, using the model specification defined by equations (17), (24) with $z = 1$, and (35), the impact of an increase in $\tilde{\tau}_h$ (τ_a) on the equilibrium probability of policy diffusion, ρ^C , is very similar to our previous findings. The following proposition summarizes our results:

Proposition 5. *Under Cournot competition, the impact of an increase in the domestic (foreign) policy level is characterized by*

$$\frac{\partial \rho^C}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{2\tilde{\tau}_h - A - \tau_a}{A - \tilde{\tau}_h} < \frac{\sigma}{\alpha} < \frac{2\omega_h - A - \tau_a}{A - \omega_h}, \\ < 0 & \text{if } \frac{\sigma}{\alpha} > \frac{2\omega_h - A - \tau_a}{A - \omega_h}, \text{ and} \end{cases} \quad (36)$$

$$\frac{\partial \rho^C}{\partial \tau_a} < 0. \quad (37)$$

Proof. See Appendix A. □

Proposition 5 again emphasizes the importance of the relative slope criterion. As it is the case for perfect competition, if the supply curve is sufficiently flat relative to the demand curve, for low domestic production levels, the probability of policy diffusion may increase in the stringency of the proposed policy at home. Note, however, that this may only be the

case for relatively severe environmental damage. If the environmental damage parameter ω_h is small, the condition for $\frac{\partial \rho^*}{\partial \tilde{\tau}_h} > 0$ cannot be fulfilled and the probability of policy diffusion always decreases in the level of environmental policy. The interval for which ρ^C can be increasing in $\tilde{\tau}_h$, however, is of the same length as the interval defined in Proposition 3 for $\frac{\partial \rho^*}{\partial \tilde{\tau}_h} > 0$. Yet the thresholds are relatively smaller in the case of Cournot competition: when there is imperfect competition, the slope of the demand curve can be relatively larger compared to the slope of the supply curve before causing the sign of the derivative to switch; i.e., when firms have market power, inelastic demand is less important in allowing for a positive marginal effect of domestic regulatory stringency. Furthermore, despite the firms' indirect influence on the world price, a marginal increase in the level of foreign regulation continues to decrease the probability of policy implementation: as the supply side effect always dominates the demand side effect, the industrial lobby is strongly opposed to domestic policy implementation following a regulatory change abroad. Its efforts trying to secure larger profits following the shift of production outpace those by the green lobby trying to prevent additional pollution and, hence, a marginal increase in the regulatory level abroad reduces the probability of policy diffusion.

4.2 Simultaneous quantity choice and quadratic environmental damage

With Cournot competition, the equilibrium production levels and world price change, which affects the stakes of both the green and the brown lobbies in country h , yet not the way they are impacted by marginal changes in the policy levels at home or abroad: the effect of stricter regulation in either country remains unambiguously positive, i.e., $\frac{\partial V_B^{QC}}{\partial \tilde{\tau}_h} > 0$, $\frac{\partial V_B^{QC}}{\partial \tau_a} > 0$, $\frac{\partial V_G^{QC}}{\partial \tilde{\tau}_h} > 0$, and $\frac{\partial V_G^{QC}}{\partial \tau_a} > 0$. Further, we find that the effect of changes in the (proposed) regulation on the probability of policy diffusion mirror our results of subsection 3.2: we find that a stricter policy proposal at home reduces the likelihood of policy diffusion while more stringent foreign regulation increases it. This is summarized in the following proposition:

Proposition 6. *If environmental damage is defined by equation (24) with $z = 2$ and there is imperfect competition with firms choosing output simultaneously, policy changes at home or abroad affect the*

equilibrium probability of policy diffusion, ρ^{QC} , as follows:

$$\frac{\partial \rho^{QC}}{\partial \tilde{\tau}_h} < 0 \text{ and} \quad (38)$$

$$\frac{\partial \rho^{QC}}{\partial \tau_a} > 0. \quad (39)$$

Proof. The proof is straightforward and therefore omitted. \square

This confirms our finding that a quadratic damage function provides sufficient incentives for the green lobby to increase the probability of policy diffusion.

4.3 Sequential quantity choice and linear environmental damage

When there is Stackelberg competition, with one industry choosing its output first, we have to distinguish between the marginal effects of policy changes when the country h is the quantity leader and when it is the follower. We analyze these two situations using subscript $t \in \{1, 2\}$: $t = 1$ denotes the industry in country h as the leader choosing its quantity produced first, and $t = 2$ denotes it as the follower reacting to the production level abroad. Our analysis is simplified by the fact that the direction of the impact of increases in either $\tilde{\tau}_h$ or τ_a on the lobbies' stakes is the same: $\frac{\partial V_{B,t}^S}{\partial \tilde{\tau}_h}$, $\frac{\partial V_{B,t}^S}{\partial \tau_a}$, $\frac{\partial V_{G,t}^S}{\partial \tilde{\tau}_h}$, and $\frac{\partial V_{G,t}^S}{\partial \tau_a}$ are all unambiguously positive. We also find that the reaction of the brown lobby to changes in τ_a is relatively stronger than that of the green lobby, hence, the probability of a policy being implemented is negatively affected by a marginal increase in the stringency of foreign regulation. This finding holds for both countries, that of the leader as well as that of the follower. When it comes to changes in the proposed level of regulation at home, however, our results are again ambiguous. Our results are summarized in the following propositions:

Proposition 7. *If environmental damage is defined by equation (24) with $z = 1$ and country h is the Stackelberg leader, changes in domestic or foreign environmental regulation affect the probability of policy diffusion as follows:*

$$\frac{\partial \rho_1^S}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{2\tilde{\tau}_h - A - \tau_a}{A - \tilde{\tau}_h} < \frac{\sigma}{\alpha} < \frac{2\omega_h - A - \tau_a}{A - \omega_h}, \\ < 0 & \text{if } \frac{\sigma}{\alpha} > \frac{2\omega_h - A - \tau_a}{A - \omega_h}, \text{ and} \end{cases} \quad (40)$$

$$\frac{\partial \rho_1^S}{\partial \tau_a} < 0. \quad (41)$$

Proof. See Appendix A.

Proposition 8. *If environmental damage is defined by equation (24) with $z = 1$ and country h is the Stackelberg follower, changes in domestic or foreign environmental regulation affect the probability of policy diffusion as follows:*

$$\frac{\partial \rho_2^S}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{-3A+4\tilde{\tau}_h-\tau_a+\sqrt{\Omega}}{2(A-\tilde{\tau}_h)} < \frac{\sigma}{\alpha} < \frac{-3A+4\omega_h-\tau_a+\sqrt{\Omega+4(2A-\tilde{\tau}_h-\omega_h)(\tilde{\tau}_h-\omega_h)}}{2(A-\omega_h)}, \\ < 0 & \text{if } \frac{\sigma}{\alpha} > \frac{-3A+4\omega_h-\tau_a+\sqrt{\Omega+4(2A-\tilde{\tau}_h-\omega_h)(\tilde{\tau}_h-\omega_h)}}{2(A-\omega_h)}, \end{cases} \quad (42)$$

where $\Omega = 4(A - \tilde{\tau}_h)^2 + (A - \tau_a)^2$, and

$$\frac{\partial \rho_2^S}{\partial \tau_a} < 0. \quad (43)$$

Proof. See Appendix A.

Given that the stakes of both lobbies are strictly increasing in the policy level $\tilde{\tau}_h$ and τ_a , the net effect of marginal change in the policy level $\tilde{\tau}_h$ (τ_a) on the probability of policy implementation is *a priori* unclear. Yet the results summarized in Propositions 7 and 8 mirror our findings for perfect and Cournot competition: the impact of a change in foreign environmental policy on the brown lobby prevails both when the industry in country h is the quantity leader as well as when it is the follower. In other words, the condition of Proposition 2 is not satisfied and the probability of policy diffusion is decreasing in foreign regulatory stringency. On the other hand and contrary to common intuition, for both cases, we again identify a range for which the probability of policy implementation in country h is increasing in the proposed level of regulation. This is due to the fact that in these parameter ranges, the impact of increased regulation on the green lobby is stronger than on the brown lobby and, hence, the condition of Proposition 1 is satisfied. Note that in the country of the Stackelberg leader, the thresholds for this to occur are exactly the same as in the case of Cournot competition. For the Stackelberg follower, we can show that the interval for which $\frac{\partial \rho_2^S}{\partial \tilde{\tau}_h}$ is positive is smaller than for the other cases, yet the upper threshold is in between those of Cournot and perfect competition: given that the Stackelberg follower has less market power than the Stackelberg leader (or a firm in Cournot competition), in order to allow for a positive marginal impact of stricter domestic regulation, inelastic demand is more important for the Stackelberg follower yet less so than in perfect competition.

4.4 Sequential quantity choice and quadratic environmental damage

We continue by analyzing Stackelberg competition when environmental damage is defined by equation (24) with $z = 2$. Subscript $t = 1$ ($t = 2$) again denotes country h 's industry as the quantity leader (follower). The marginal impacts of policy changes at home or abroad remain unambiguously positive: $\frac{\partial V_{B,t}^{QS}}{\partial \tilde{\tau}_h} > 0$, $\frac{\partial V_{B,t}^{QS}}{\partial \tau_a} > 0$, $\frac{\partial V_{G,t}^{QS}}{\partial \tilde{\tau}_h} > 0$, and $\frac{\partial V_{G,t}^{QS}}{\partial \tau_a} > 0$ with $t \in \{1, 2\}$. The effects of regulatory changes on the probability of policy diffusion, however, are partly surprising: while our results for $t = 1$ remain in line with our findings in subsections 3.2 and 4.2, the effect of a stricter policy proposal by the regulator in country h on the probability of its implementation is—just like for a linear specification of the damage function—now ambiguous. This is summarized in the following propositions:

Proposition 9. *If environmental damage is defined by equation (24) with $z = 2$ and the industry in country h is the Stackelberg leader, policy changes at home or abroad affect the equilibrium probability of policy diffusion, ρ_1^{QS} , as follows:*

$$\frac{\partial \rho_1^{QS}}{\partial \tilde{\tau}_h} < 0 \text{ and} \quad (44)$$

$$\frac{\partial \rho_1^{QS}}{\partial \tau_a} > 0. \quad (45)$$

Proof. The proof is straightforward and therefore omitted. \square

Proposition 10. *If environmental damage is defined by equation (24) with $z = 2$ and the industry in country h is the Stackelberg leader, policy changes at home or abroad affect the equilibrium probability of policy diffusion, ρ_2^{QS} , as follows:*

$$\frac{\partial \rho_2^{QS}}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{-3A+4\tilde{\tau}_h-\tau_a+\sqrt{4(A-\tilde{\tau}_h)^2+(A-\tau_a)^2}}{2(A-\tilde{\tau}_h)} < \frac{\sigma}{\alpha} < \frac{-3A+4\omega_h-\tau_a+\sqrt{4(A-\omega_h)^2+(A-\tau_a)^2}}{2(A-\omega_h)}, \\ < 0 & \text{if } \frac{\sigma}{\alpha} > \frac{-3A+4\tilde{\tau}_h-\tau_a+\sqrt{4(A-\omega_h)^2+(A-\tau_a)^2}}{2(A-\omega_h)}, \end{cases} \quad (46)$$

$$\frac{\partial \rho_2^{QS}}{\partial \tau_a} > 0. \quad (47)$$

Proof. The proof is straightforward and therefore omitted. \square

Condition (46) mirrors our findings for Stackelberg competition and linear environmental damage. In fact, the interval defined by (46) is greater than that defined by (42), therefore, there is a greater parameter range for which the chances of policy implementation at home

increase in the policy's stringency. Being the Stackelberg follower, firm h produces relatively little; with strict foreign regulation, the world price is high and if demand is sufficiently inelastic—the demand curve is sufficiently steep compared to the supply curve—a marginally stricter policy proposal $\tilde{\tau}_h$ can have a stronger effect on the political stake of the green lobby than on that of the brown lobby. In this case, the probability of policy diffusion is increasing in the stringency of domestic regulation. If, on the other hand, the supply curve is sufficiently steep, a stricter policy proposal has the commonly expected effect of decreasing the probability of implementation.

5 Heterogeneous production cost

Given our focus on the differences in regulatory cost, so far we assumed that production technologies are homogeneous, i.e., that cost parameter σ is the same in both countries. While this assumption allowed us to focus on the important role of the damage function, it also did not fully reflect the potential competitive (dis)advantages of a country h . Our model, however, is easily extended to the case of heterogeneous cost where σ_j reflects the cost (and technology) of production in country $j \in J$. We show that the difference in production cost between home and abroad, which can be partly offset (or exacerbated) by environmental regulation, is an important driver of policy diffusion. For our analysis, we assume perfect competition where marginal production cost as derived from

$$c_j^{HC}(x_j(\tau_j, \tau_{-j}, \tau_j)) = \frac{1}{2} \cdot \sigma_j \cdot x_j(\tau_j, \tau_{-j})^2 + \tau_j \cdot x_j(\tau_j, \tau_{-j}), \quad (48)$$

defines domestic supply while inverse demand is given by (17).

5.1 Linear environmental damage and heterogeneous cost

Again, we focus on country h and start by assuming that environmental damage is determined by equation (24) with $z = 1$. Similar to our results in subsection 3.1, we find that stricter regulation in either country increases the stakes of both lobbies, i.e., $\frac{\partial V_B^{HC}}{\partial \tilde{\tau}_h} > 0$, $\frac{\partial V_B^{HC}}{\partial \tau_a} > 0$, $\frac{\partial V_G^{HC}}{\partial \tilde{\tau}_h} > 0$, and $\frac{\partial V_G^{HC}}{\partial \tau_a} > 0$. As a result, the effect of marginal policy changes on the equilibrium probability of policy diffusion, ρ^{HC} , is a priori unclear. We show that when the environmental

damage function is linear, marginally stricter policies abroad always have a stronger effect on the brown lobby than on the green lobby and, hence, its impact on the probability of policy diffusion is always negative. The effect of a stricter policy proposal by the domestic regulator, on the other hand, is ambiguous as the following proposition shows:

Proposition 11. *Given heterogeneous production cost, a change in the stringency of regulation (at home or abroad) has the following effect on the probability of policy implementation:*

$$\frac{\partial \rho^{HC}}{\partial \tilde{\tau}_h} \begin{cases} > 0 & \text{if } \frac{\tilde{\tau}_h - \tau_a}{A - \tilde{\tau}_h} < \frac{\sigma_a}{\alpha} < \frac{\omega_h - \tau_a}{A - \omega_h}, \\ < 0 & \text{if } \frac{\sigma_a}{\alpha} > \frac{\omega_h - \tau_a}{A - \omega_h} \end{cases} \quad \text{and} \quad (49)$$

$$\frac{\partial \rho^{HC}}{\partial \tau_a} < 0. \quad (50)$$

Proof. See Appendix A.

Note that a crucial factor here is the slope of the supply curve in the foreign country. σ_a , of course, is an important determinant of the comparative (dis)advantage of the industry in country h and, therefore, of its production level. Large levels of σ_a lead to an increase in domestic production, thereby raising the stake of the brown lobby. As a result, the ratio of the slopes of foreign supply and global demand may exceed the threshold defined in condition (49), in which case a marginally stricter policy proposal reduces the probability of its implementation as the industry expands more effort into maintaining its competitive advantage. In short, contrary to what one might expect, a change in the proposed domestic policy level only increases the likelihood of policy diffusion if the competitive advantage of the domestic industry is not too strong while environmental damage (as captured by ω_h) is sufficiently severe.

5.2 Quadratic environmental damage and heterogeneous cost

The results of subsection 3.2 are hardly changed by allowing for heterogeneous non-regulatory production cost as defined in (48). The results of Lemmas 1 and 3 remain unchanged, i.e., the impact of marginal changes in the stringency of regulation on the political stakes of the lobbies is unambiguously positive. Moreover, just as in subsection 3.2, changes in the stringency of the (proposed) policy levels at home or abroad have unambiguous effects on the probability of policy diffusion, ρ^{QHC} . This is summarized in the following proposition:

Proposition 12. *If environmental damage is defined by equation (24) with $z = 2$ and the industries in the two countries face different production costs defined by equation 48, policy changes at home or abroad affect the equilibrium probability of policy diffusion, ρ^{QHC} , as follows:*

$$\frac{\partial \rho^{QHC}}{\partial \tilde{\tau}_h} < 0 \text{ and} \quad (51)$$

$$\frac{\partial \rho^{QHC}}{\partial \tau_a} > 0. \quad (52)$$

Proof. The proof is straightforward and therefore omitted. □

6 Conclusion

The purpose of this paper is to analyze the influence of special interest groups on the stringency of environmental regulation in an open economy. When the output of their industries is traded freely, differences in the countries' regulatory standards give rise to concerns regarding their respective competitiveness. Nevertheless, we often observe the diffusion of environmental policies from one jurisdiction to others. While a number of potential explanations have been offered, we suggest that special interest groups may play a crucial role in policy diffusion. We investigate how lobbying efforts, regulatory stringency and ensuing output in one country are affected by a change in environmental policy abroad. In doing so, we aim to fill a void in the literature, which has yet to study the political economy of policy diffusion when countries act unilaterally.

First, we develop a general framework with an open economy that is regulated by an independent, non-cooperative government, which is influenced by two opposing lobby groups. We identify the relative elasticity of the interest groups' lobbying efforts with respect to a policy change as a crucial determinant of the political equilibrium. Second, using functional forms, we then identify under which circumstances competing countries may unilaterally adopt stricter regulatory standards and highlight the importance of the type of pollutant for the political equilibrium. Assuming perfect competition and given local pollution and linear environmental damage, we find that relatively inelastic demand (the demand curve is steeper than the supply curve) ensures that a marginal increase in the stringency of domestic regulation can increase the probability of stricter regulation. Strict policies in the rest of the world,

however, are typically not sufficient to motivate similar regulation in the home country. This result changes dramatically when the environmental damage function is convex: as the lobbying incentive of the environmental interest group increases, its reaction to stricter foreign regulation, which shifts production to the domestic market, now suffices to increase the probability of policy diffusion. In other words, if the impact of pollution is sufficiently harmful, a country can assume a leadership role (with respect to regulating pollution) among freely trading countries and motivate similar policies abroad.

Third, we extend our analysis to cases of imperfect competition and heterogeneous cost, which, for many real world situations, may be a more suitable description of the market structure. While the change in market structure, of course, alters our results, our main findings remain unchanged: with local pollution, stricter regulation abroad strictly decreases the probability of policy diffusion whereas a more stringent policy proposal by the regulator in country h may actually increase its chances of implementation.

As the global economy becomes increasingly integrated, understanding the impact of trade on the environment gains importance. The analysis of this relationship is incomplete without considering the interplay of environmental regulation and competitiveness—a potential cause for policy races—as well as the prominent role played by special interest groups. In this paper, we have developed a framework that allows for such analysis and our results illustrate the complexity of the trade-environmental policy nexus. We highlight market structure and the nature of the pollutant as two important factors determining the likelihood of policy diffusion. Considering these factors (among others) would add significant depth to the public debate about trade and the environment, which often seems overly generalizing as the recent discussion of the *Transatlantic Trade and Investment Partnership (TTIP)* and the *Trans-Pacific Partnership (TPP)* have shown.¹²

Finally, in addition to our results that facilitate the analysis of environmental policies under free trade, our general model of Section 2 could contribute to future research that may include, e.g., the analysis of strategic behavior by the regulator, economies of different sizes or the incentive structure of the lobbies when pollution is transboundary.

¹²See, for example, “What does the biggest free trade deal in history mean for the environment” in *The Guardian*, March 14, 2014, or “TTIP Could Weaken Chemical Rules, Environmental Groups Say” in *The Wall Street Journal*, October 7, 2014.

A Mathematical Appendix

Proof of Proposition 3 By use of equation (19), the following holds:

$$x_h^* > 0 \Leftrightarrow \frac{\sigma}{\alpha} > \underbrace{\frac{\tilde{\tau}_h - \bar{\tau}_a}{A - \tilde{\tau}_h}}_{\Lambda_1}.$$

Differentiation of ρ^* with respect to $\tilde{\tau}_h$ yields

$$\frac{\partial \rho^*}{\partial \tilde{\tau}_h} > 0 \Leftrightarrow \frac{\sigma}{\alpha} < \underbrace{\frac{\omega_h - \bar{\tau}_a}{A - \omega_h}}_{\Lambda_2}.$$

It is straightforward to show that $\Lambda_2 > \Lambda_1$. Condition (28) immediately follows. Finally, condition (29) follows directly from the differentiation of ρ^* with respect to $\bar{\tau}_a$. \square

Proof of Proposition 5 For an interior solution, we require a positive production level:

$$x_h^C > 0 \Leftrightarrow \frac{\sigma}{\alpha} > \underbrace{\frac{2\tilde{\tau}_h - A - \bar{\tau}_a}{A - \tilde{\tau}_h}}_{\Lambda_3}.$$

By use of condition (12), the following holds:

$$\frac{\partial \rho^C}{\partial \tilde{\tau}_h} > 0 \Leftrightarrow \frac{\sigma}{\alpha} < \underbrace{\frac{2\omega_h - A - \bar{\tau}_a}{A - \omega_h}}_{\Lambda_4}.$$

Given that $\Lambda_4 > \Lambda_3$, condition (36) directly follows. Moreover, condition (37) is straightforward from the differentiation of ρ^C with respect to $\bar{\tau}_a$. \square

Proof of Proposition 7 For an interior solution, the following has to hold:

$$x_{h,1}^S > 0 \Leftrightarrow \frac{\sigma}{\alpha} > \underbrace{\frac{2\tilde{\tau}_h - A - \bar{\tau}_a}{A - \tilde{\tau}_h}}_{\Lambda_5}.$$

Application of condition (12) yields

$$\frac{\partial \rho_1^S}{\partial \tilde{\tau}_h} > 0 \Leftrightarrow \frac{\sigma}{\alpha} < \underbrace{\frac{2\omega_h - A - \bar{\tau}_a}{A - \omega_h}}_{\Lambda_6}.$$

It is easy to show that $\Lambda_6 > \Lambda_5$. Condition (40) directly follows. Condition (41) follows from the differentiation of ρ_1^S with respect to $\bar{\tau}_a$. \square

Proof of Proposition 8 For an interior solution, the following has to hold:

$$x_{h,2}^S > 0 \Leftrightarrow \frac{\sigma}{\alpha} > \underbrace{\frac{-3A + 4\tilde{\tau}_h - \bar{\tau}_a + \sqrt{4(A - \tilde{\tau}_h)^2 + (A - \bar{\tau}_a)^2}}{2(A - \tilde{\tau}_h)}}_{\Lambda_7}.$$

Using condition (12), we find:

$$\frac{\partial \rho_2^S}{\partial \tilde{\tau}_h} > 0 \Leftrightarrow \frac{\sigma}{\alpha} < \underbrace{\frac{-3A + 4\omega_h - \bar{\tau}_a + \sqrt{4(A - \tilde{\tau}_h)^2 + (A - \bar{\tau}_a)^2 + 4(2A - \tilde{\tau}_h - \omega_h)(\tilde{\tau}_h - \omega_h)}}{2(A - \omega_h)}}_{\Lambda_8}.$$

Condition (42) directly follows from the fact that $\Lambda_8 > \Lambda_7$. Finally, condition (43) is the immediate result of the differentiation of ρ_1^S with respect to $\bar{\tau}_a$. \square

Proof of Proposition 11 For an interior solution, we require a positive production level:

$$x_h^{HC} > 0 \Leftrightarrow \frac{\sigma_a}{\alpha} > \underbrace{\frac{\tilde{\tau}_h - \bar{\tau}_a}{A - \tilde{\tau}_h}}_{\Lambda_9}.$$

By use of condition (12), the following holds:

$$\frac{\partial \rho^{HC}}{\partial \tilde{\tau}_h} > 0 \Leftrightarrow \frac{\sigma_a}{\alpha} < \underbrace{\frac{\omega_h - \bar{\tau}_a}{A - \omega_h}}_{\Lambda_{10}}.$$

It is straightforward to show that $\Lambda_{10} > \Lambda_9$, hence, condition (49) immediately follows. Condition (50) is straightforward from the differentiation of ρ^C with respect to $\bar{\tau}_a$. \square

B Extension: The lobby contest with a generalized lottery function

The results we derived in Section 2 are easily replicated using a more general contest success function, namely the generalized lottery function that allows for varying degrees of returns to lobbying. The success probabilities for the green and brown lobby groups are then given by

$$\rho_r = \frac{k_G^r}{k_G^r + k_B^r} \text{ and } (1 - \rho_r) = \frac{k_B^r}{k_G^r + k_B^r}, \quad (\text{B.1})$$

where $k_G, k_B > 0$ and where parameter r captures the return to effort by the lobby groups.

Following the extensive literature on contests, it is again straightforward to derive the equilibrium values for the lobby groups' efforts, the probability of policy implementation, and expected net payoffs (e.g., Nti, 1999; Konrad, 2009). They are given by

$$\begin{aligned} k_{l,r}^* &= \frac{rV_l^{1+r}V_{-l}^r}{(V_l^r + V_{-l}^r)^2} \\ \rho_r^* &= \frac{V_G^r}{V_G^r + V_B^r} \\ \Pi_{G,r}^* &= \hat{\Pi}_{G,r} + \frac{V_G^{r+1}(V_B^r(1-r) + V_G^r)}{(V_B^r + V_G^r)^2} \\ \Pi_{B,r}^* &= \tilde{\Pi}_{B,r} + \frac{V_B^{r+1}(V_B^r + V_G^r(1-r))}{(V_B^r + V_G^r)^2} \end{aligned}$$

We are again mainly interested in the effect of changes in the (proposed) level of environmental policy—both domestically and abroad—on the probability of stricter regulation being passed in country h . In other words, we are interested in $\frac{\partial \rho_r}{\partial \tilde{\tau}_h}$ and $\frac{\partial \rho_r}{\partial \tau_a}$, which are given by

$$\frac{\partial \rho_r}{\partial \tilde{\tau}_h} = \frac{r(V_B V_G)^{r-1} \left(\frac{\partial V_G}{\partial \tilde{\tau}_h} V_B - \frac{\partial V_B}{\partial \tilde{\tau}_h} V_G \right)}{(V_B^r + V_G^r)^2} \text{ and } \frac{\partial \rho_r}{\partial \tau_a} = \frac{r(V_B V_G)^{r-1} \left(\frac{\partial V_G}{\partial \tau_a} V_B - \frac{\partial V_B}{\partial \tau_a} V_G \right)}{(V_B^r + V_G^r)^2}.$$

The conditions for these derivatives to be positive are identical to the conditions we derived in section 2 for the case of $r = 1$.¹³ Therefore, even though we limited the analysis in Sections 3-5.1 to the case of Tullock's standard logit contest success function with $r = 1$, the results apply to a much broader array of contest specifications.

¹³Note that our results also extend to the discriminating Tullock contest in which the success probability of lobby l is given by $\rho_l = \frac{k_l^r}{k_l^r + m \cdot k_{-l}^r}$, where the parameter m captures the relative (dis)advantage of the opposing lobby group.

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