Green Protection for Sale: The Impact of Industrial Lobbying on International Cooperation in the Presence of Border Carbon Adjustment

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Abstract We study the influence of producer firm lobby groups on the choice of national emission reduction policies and the formation of a climate coalition if members of the coalition use border carbon adjustments (BCA). Coalition countries regulate emissions from commodity production with a carbon tax. The commodity is traded on an international market. We find that lobbying leads to a reduction of the price difference between coalition countries and outsiders and can thereby help to stabilize larger coalitions. We contribute to the literature by providing novel insights how, in the presence of BCA, industry lobbies can improve the prospects for climate cooperation. In this case, "green protection for sale" turns into environmental protection.

Keywords Carbon Leakage · Climate Change · Environmental Policy · Lobbying · International Environmental Agreements · Border Carbon Adjustment

JEL Classification D72 · F13 · F18 · H23 · Q54 · Q56 · Q58

1 Introduction

Reducing greenhouse gas emissions to mitigate dangerous anthropogenic climate change that would cause severe economic damages (Stern 2007) is a challenging international problem that has not been resolved so far. Greenhouse gas emissions are a global public bad, which hampers cooperative efforts in absence of a binding global climate regime. Strong free-rider incentives prevent countries from joining large and effective binding international environmental agreements (IEA), which is a well known result in the economic literature (Hoel 1992, Barrett 1994). At the same time, unilateral climate policies lead to carbon leakage, which compromises the effectiveness and efficiency of such measures. A border carbon adjustment (BCA) provides a means to reduce carbon leakage and negative competitiveness effects for producers in countries with stringent climate policies (OECD 2020, Fischer & Fox 2012). Further, it has been shown that trade sanctions against non-participants have the potential to increase participation in IEAs (Lessmann et al. 2009, Nordhaus 2015), a result that also holds with BCA as a specific form of trade measure (Al Khourdajie & Finus 2020, Schopf 2020). However, as long as they do not help to stabilize the grand coalition that applies a uniform climate policy (which would in turn imply that they are actually not implemented), BCAs do not come without a cost. They can increase trade distortions and could even be regarded as some form of "green protectionism" (OECD 2020).

Our study contributes to several streams of literature. Previous studies on measures to reduce carbon leakage built on seminal work of Markusen (1975), who analyzed an optimal combination of an emission tax with an import tariff, depending on leakage and terms-of-trade effects. The optimal policy choice to prevent leakage has been further studied inter alia by Copeland (1996) and Hoel (1996), and more recently by Keen & Kotsogiannis (2014) and Böhringer et al. (2017). A large number of contributions use numerical computable general equilibrium (CGE) models for quantifications of leakage effects and the effectiveness and efficiency of BCAs, see Zhang (2012) and Branger & Quirion (2014) for reviews of this literature. The most relevant difference between these previous contributions and our study is that they assume welfare maximizing governments without the influence of special interest groups and do not consider the formation of international environmental agreements.

Further, our work clearly contributes to the literature on IEAs and trade. While seminal papers on self-enforcing IEAs (Carraro & Siniscalco 1993, Hoel 1992, Barrett 1994) did not consider trade effects, Eichner & Pethig (2013) extended the basic model to explicitly study international trade. Eichner & Pethig (2014), Eichner & Pethig (2015*a*), and Eichner & Pethig (2015*b*) consider different variants concerning the timing of the game and the choice of supply- or demand-side policies, but none of these contributions analyzes the introduction of tariffs. To the best of our knowledge, the first study that considers trade sanctions in an IEA model is Barrett (1997). However, he only includes a complete trade ban together with a minimum participation clause, which leads to the stabilization of the grand coalition. Using numerical simulations, Lessmann et al. (2009), Nordhaus (2015), and Böhringer et al. (2016) studied trade sanctions as an effective means to stabilize climate coalitions and Hagen & Schneider (2017) show that the effect of trade sanctions on coalition stability is ambiguous if outsiders retaliate. Helm & Schmidt (2015), Schopf (2020), Baksi & Chaudhuri (2020), and Al Khourdajie & Finus (2020) confirm the stabilizing effect of BCAs on climate coalitions. In contrast to our work, none of these studies considers the effect of lobbying on policy making.

Our third contribution is to the literature on the influence of lobbying on environmental policy making. Here, a number of studies have built on the common-agency approach by Grossman & Helpman (1994), including Aidt (1998), and Fredriksson & Svensson (2003). Schopf & Voss (2019) and Voss & Schopf (2021) study the influence of lobbying on environmental policies in a dynamic setting. Voss & Schopf (2021) find that industry lobbying can lead to a reduction of environmental damages. However, they analyze a closed economy and therefore neither consider trade effects and carbon leakage nor coalition formation. Habla & Winkler (2013) study a two-country model of an international permit market under the influence of lobby groups, and, considering the effects of lobbying on the formation of IEAs, Marchiori et al. (2017) and Hagen et al. (2020) show that the influence of lobby groups can have either a stabilizing or a destabilizing effect on climate coalitions, depending on the distribution of lobby groups and the timing of lobbying. However, Marchiori et al. (2017) and Hagen et al. (2020) do neither explicitly account for production and consumption, nor for international trade and none of these studies considers the strategic use of BCAs. Closest to our paper, Conconi (2003) analyzes the interaction of environmental and trade policies in the presence of lobby groups and emission leakage under different trade regimes. However, because the analysis is restricted to two countries, the study does not provide insights on the formation of IEAs, which is our focus. To the best of our knowledge, we are the first to provide an integrated analysis of lobbying influence on trade and environmental policies in a setting with more than two countries. We apply the partial equilibrium framework of

Hoel (1994), which we extend both by a model of coalition formation with n countries and by the inclusion of BCA. We apply the common-agency approach of Grossman & Helpman (1994) to study the influence of producer lobbies on carbon taxes to reduce emissions and on coalition formation.

We find that BCA ceteris paribus induces the fringe countries to increase their carbon taxes, because this reduces emissions from the coalition countries. Furthermore, it induces the coalition countries to increase their carbon tax, because this effectively reduces demand and, thus, reduces emissions from the fringe countries. However, the tax difference implies that a fringe country's welfare exceeds that of a coalition country, such that the stable coalition typically consists of no more than three countries.

This changes with lobbying from the industry. In the fringe countries, these lobbies prefer a positive carbon tax to reduce supply and, thus, to increase the price. By contrast, in the coalition countries, industry lobbies prefer a carbon subsidy, which effectively increases demand and, thus, raises the price. Ceteris paribus, this reduces the tax difference and, thus, the welfare difference, and the stable coalition can become larger. In an example, we find that coalition of 9 countries is stable in an economy of 20 countries.

To verify that these positive results of lobbying are indeed driven by the border carbon adjustment, we also conduct an analysis with carbon taxes only. In this case, the stable coalition typically consists of no more than three countries, with or without lobbying.

In the remainder of the paper we describe the basic model in Section 2 and introduce BCA in Section 3 and lobbying in Section 4. In Section 5 we compare our results to a scenario without BCA before we conclude in Section 6.

2 The model

In what follows, we apply Hoel's (1994) partial equilibrium framework extended by coalition formation and border carbon adjustment.[1] Consider a trade model with n countries. In each country $i \in N$, the respective representative household derives benefits $B_i(y_i)$ from commodity consumption y_i, where $B_i' > 0$ and $B_i'' < 0$, and the respective representative firm faces costs $C_i(x_i)$ of commodity production x_i, where $C_i', C_i'' > 0$. Emissions are proportional to commodity production, and i faces climate costs $H_i(x)$ from global emissions

[1] Harstad (2012, Section 2) shows that this model can be extended to a general equilibrium model without changing the results.

$x \coloneqq \sum_{j\in N} x_j$, where $H_i' > 0$ and $H_i'' \geq 0$. The commodity is traded on an international market at the commodity price p. The market clearing condition is $\sum_{j\in N} y_{j\in N} = \sum_j x_j$.

Suppose that m countries represent the environmental coalition E, whereas the remaining $n-m$ countries represent the fringe F. The coalition uses a common carbon tax χ_e, whereas each fringe country uses an individual carbon tax χ_i. Furthermore, the coalition implements border carbon adjustment in the form of a common trade tax $\tau_e = \phi(\chi_e - \chi_f) \geq 0$, where $\phi \in [0,1]$ is the exogenous adjustment parameter and $\chi_f \coloneqq \sum_{j\in F} \frac{\chi_i}{n-m}$ is the average carbon tax of the fringe countries.[2] The respective tax revenue is returned to the respective representative household and to the respective representative firm as a lump-sum transfer

$$T_i = \begin{cases} \chi_i x_i = T_i^x & \text{for } i \in F, \\ \chi_e x_i + \tau_e(y_i - x_i) = \tau_e y_i + (\chi_e - \tau_e)x_i = T_i^y + T_i^x & \text{for } i \in E. \end{cases} \tag{1}$$

The representative households and firms take the commodity price, the taxes and the lump-sum transfers as given and do not consider the climate costs. Their consumption and production decisions follow from

$$\max_{y_i} B_i(y_i) - py_i \text{ and } \max_{x_i} px_i - C_i(x_i) - \chi_i x_i + T_i^x \qquad \text{for } i \in F, \tag{2}$$

$$\max_{y_i} B_i(y_i) - py_i - \tau_e y_i + T_i^y \text{ and } \max_{x_i} px_i - C_i(x_i) - (\chi_e - \tau_e)x_i + T_i^x \qquad \text{for } i \in E, \tag{3}$$

which implies

$$p = \begin{cases} B_i'(y_i) = C_i'(x_i) + \chi_i & \text{for } i \in F, \\ B_i'(y_i) - \tau_e = C_i'(x_i) + (\chi_e - \tau_e) & \text{for } i \in E. \end{cases} \tag{4}$$

Rearranging (4) yields the respective representative household's commodity demand and the respective representative firm's commodity supply

$$y_i = \begin{cases} D_i(p) & \text{for } i \in F, \\ D_i(p+\tau_e) & \text{for } i \in E, \end{cases} \quad \text{and} \quad x_i = \begin{cases} S_i(p - \chi_i) & \text{for } i \in F, \\ S_i(p - \chi_e + \tau_e) & \text{for } i \in E, \end{cases} \tag{5}$$

where $D_i \coloneqq B_i'^{-1}$ and $S_i \coloneqq C_i'^{-1}$ with $D_i' = \frac{1}{B_i''} < 0$ and $S_i' = \frac{1}{C_i''} > 0$. Note that $\phi > 0$ implies that consumption in the coalition countries is effectively taxed, and that $\phi = 1$ implies that production in the coalition countries is effectively taxed at the average carbon

[2] If the coalition imports [exports] the commodity, then $\tau_e > 0$ is an import tax [export subsidy].

tax of the fringe countries. Using (5) in the market clearing condition yields

$$\sum_{j\in F} D_j(p) + \sum_{j\in E} D_j(p+\tau_e) = \sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j(p-\chi_e+\tau_e). \tag{6}$$

Totally differentiating (6) for $\tau_e = \phi\left(\chi_e - \sum_{j\in F}\frac{\chi_i}{n-m}\right)$ and rearranging yields

$$\frac{\partial p}{\partial \chi_i} = \begin{cases} \dfrac{S_i' + \phi\sum_{j\in E}(S_j' - D_j')/(n-m)}{S' - D'} \in (0,1) & \text{for } i \in F, \\ \dfrac{\sum_{j\in E} S_j' - \phi\sum_{j\in E}(S_j' - D_j')}{S' - D'} \in (-1,1) & \text{for } i \in E, \end{cases} \tag{7}$$

where $D' := \sum_{j\in N} D_j'$ and $S' := \sum_{j\in N} S_j'$. For $\phi = 0$, a fringe country's carbon tax reduces its supply, which increases the price. For $\phi > 0$, it additionally reduces the border carbon adjustment, which reduces supply and raises demand in the coalition countries and, thus, further increases the price. Moreover, for $\phi = 0$, the coalition countries' carbon tax reduces their supply, which increases the price. For $\phi > 0$, it additionally raises the border carbon adjustment, which raises supply and reduces demand in the coalition countries and, thus, reduces the price.

Throughout the paper, we assume that all countries take the carbon taxes in all other countries as given, i.e. we solve for the Nash equilibrium. Note that the border carbon adjustment depends on all carbon taxes, such that all countries account for their influence on the coalition's trade tax via their carbon taxes. Furthermore, we assume that all countries account for their influence on the commodity price.

3 Border carbon adjustment

Each fringe country's optimal policy follows from maximizing its welfare, i.e. its benefits from commodity consumption minus its costs of commodity production minus its climate costs plus its trade revenues,

$$\begin{aligned} W_i = {} & B_i[D_i(p)] - C_i[S_i(p-\chi_i)] - H_i\Big[\sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j(p-\chi_e+\tau_e)\Big] \\ & + p[S_i(p-\chi_i) - D_i(p)], \end{aligned} \tag{8}$$

with respect to its carbon tax subject to $\tau_e = \chi_e - \frac{\sum_{j\in F}\chi_i}{n-m}$ and (7). In Appendix A.1, we solve the maximization problem and find

$$\chi_i = H_i' - \underbrace{\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{\sum_{j\in N\setminus i} S_j'}{S_i'}H_i'}_{CL_i} - \underbrace{\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{1}{S_i'}(y_i - x_i)}_{ToT_i} + \underbrace{\frac{1}{1-\frac{\partial p}{\partial \chi_i}}\frac{\sum_{j\in E} S_j'}{(n-m)S_i'}H_i'}_{BCA_i}. \tag{9}$$

Thus, the carbon tax accounts for the fringe country's climate externality on itself (H_i'), but also for the increase in foreign emissions (CL_i) and for the increase in its export revenues or import costs (ToT_i) induced by the decrease in its commodity supply and, thus, the increase in the commodity price. Furthermore, the carbon tax induces the coalition countries to partially account for their climate externality on the fringe country via the border carbon adjustment, which speaks in favor of a higher carbon tax (BCA_i).

The coalition countries' optimal policy follows from maximizing their joint welfare, i.e. their benefits from commodity consumption minus their costs of commodity production minus their climate costs plus their trade revenues,

$$\begin{aligned}\sum_{j\in E} W_j = &\sum_{j\in E} B_j[D_i(p)] - \sum_{j\in E} C_j[S_j(p-\chi_e)] \\ &- \sum_{j\in E} H_j\Big[\sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j(p-\chi_e+\tau_e)\Big] \\ &+ p\sum_{j\in E}[S_j(p-\chi_e+\tau_e) - D_j(p-\tau_e)],\end{aligned} \tag{10}$$

with respect to their carbon tax subject to $\tau_e = \chi_e - \chi_f$ and (7). In Appendix A.1, we solve the maximization problem and find

$$\begin{aligned}\chi_e = \chi_f &+ \underbrace{\frac{\frac{\partial p}{\partial \chi_e}}{1+\frac{\partial p}{\partial \chi_e}} \frac{\sum_{j\in F} S_j'}{\sum_{j\in E} D_j'} \sum_{j\in E} H_j'}_{CL_e} - \underbrace{\frac{\frac{\partial p}{\partial \chi_e}}{1+\frac{\partial p}{\partial \chi_e}} \frac{1}{\sum_{j\in E} D_j'} \sum_{j\in E}(x_j - y_j)}_{ToT_e} \\ &+ \underbrace{\frac{\frac{\partial p}{\partial \chi_e}}{1+\frac{\partial p}{\partial \chi_e}} \frac{\sum_{j\in E} S_j'}{\sum_{j\in E} D_j'} \Big(\sum_{j\in E} H_j' - \chi_f\Big)}_{BCA_e}.\end{aligned} \tag{11}$$

Since the coalition countries take the carbon taxes in the fringe countries and, thus, their own effective carbon tax χ_f as given, they chose their nominal carbon tax χ_e to regulate their commodity demand via their effective consumption tax $\tau_e = \chi_e - \chi_f$. This effective consumption tax accounts for the decrease in foreign emissions (CL_e) and for the decrease in the coalition countries' export revenues or import costs (ToT_e) induced by the decrease in their commodity demand and, thus, in the commodity price. Without these effects, the coalition countries' effective consumption tax would just internalize their climate externality on themselves (BCA_e): If their actual effective carbon tax χ_f falls short of this climate externality ($\sum_{j\in E} H_j'$), then the coalition countries increase their effective consumption tax to reduce the commodity price and, thus, their commodity supply in order to partially offset the underinternalization of their climate externality on themselves.

To gain further insights into the signs and the magnitudes of the taxes, we now consider the following symmetric specification

$$B_i(y_i) = B_j(y_i), \quad C_i(x_i) = C_j(x_i), \quad H_i(x) = H_j(x), \qquad \forall i, j \in N, \tag{12}$$

such that $x_i = x_e$, $y_i = y_e$ for all $i \in E$ and $x_i = x_f$, $y_i = y_f$ for all $i \in F$. For later reference, we prove in Appendix A.1

Lemma 1. *Consider the symmetric specification* (12) *with* $m = n - 1$. *Then,* $\chi_e = \chi_f = nH_i'$ *and* $y_e = y_f = x_e = x_f$ *is a coalition-fringe equilibrium with full border carbon adjustment, which coincides with the fully cooperative solution.*

The intuition behind the Lemma is that a single fringe country is capable to let all other (coalition) countries perfectly internalize their climate externality on the single fringe country. Therefore, the climate part of χ_f is equal to $H_i' + mH_i' = nH_i'$. Then, the climate part of χ_e becomes zero: The tax of the single fringe country perfectly internalizes the climate externality on the coalition countries. Consequently, if there are no terms-of-trade effects, then χ_f and χ_e coincide, and if χ_f and χ_e coincide, then there are no terms-of-trade effects, such that $\chi_f = \chi_e = nH_i'$ is an equilibrium.

Indicating the coalition-fringe equilibrium with full border carbon adjustment by a check, the fully cooperative solution by an asterisk, and the fully uncooperative solution by a circle, we prove in Appendix A.1

Proposition 1. *Consider the symmetric specification* (12) *with* $m \leq n - 2$. $m/n \leq 1 - n^{-0.5}$ *implies* $\check{\chi}_e > \check{\chi}_f$, *and* $\check{\chi}_e > \check{\chi}_f$ *implies* $\check{y}_e < \check{y}_f$, $\check{x}_e = \check{x}_f$ *and* $\check{W}_e < \check{W}_f$.

Since the countries are symmetric and production is effectively taxed by χ_f in all countries, production of the countries coincides. Since the producer surpluses and the climate damages of the countries coincide but the fringe countries' consumer surpluses exceed those of the coalition countries, the welfare of each fringe country exceeds that of each coalition country. However, we cannot exclude cases in which the border carbon adjustment becomes negative for $m/n \leq 1 - n^{-0.5}$ with general functional forms. Therefore, we now consider the following linear-quadratic specification

$$B_i(y_i) = ay_i - \frac{b}{2}y_i^2, \quad C_i(x_i) = \frac{c}{2}x_i^2, \quad H_i(x) = hx, \tag{13}$$

such that $S_i' = 1/c$, $D_i' = -1/b$ and $H_i' = h$. Then, we prove in Appendix A.1[3]

[3] All quantities are positive if $b > \underline{\underline{b}}$ and $a > nh$.

Proposition 2. *Consider the linear-quadratic specification* (13) *with* $m \leq n-2$. *Suppose* $b > \underline{\underline{b}}(< c)$, *such that* $\check{\chi}_e > \check{\chi}_f$ *holds for all* $m \leq n-2$.

- $\check{\chi}_e$ *is positive for all* $m \leq n-2$ *if and only if* $b > \underline{b}(< c)$, *where* $\underline{b} > \underline{\underline{b}}$ *for* $n \geq 4$. $\check{\chi}_f$ *is positive if and only if* $m < 0.62n$, *and it is decreasing in* m *if* $b \geq \underline{b}$. $\check{\chi}_e - \check{\chi}_f$ *is increasing in* m.
- *Each coalition country's consumption* ($\check{y}_e > y_i^*$) *falls short of that in the fully uncooperative solution and is decreasing in* m *if* $b \geq \underline{b}$ *and* $m \leq n-4$, *each fringe country's consumption* ($\check{y}_f > y_i^\circ > y_i^*$) *is increasing in* m, *and* $\check{y}_e - \check{y}_f$ *is decreasing in* m.
- *Each country's production* ($\check{x}_i > x_i^*$) *falls short of that in the fully uncooperative solution and is decreasing in* m *if* $b \geq \underline{b}$ *and* $m \leq n-4$.
- *Total trade is increasing in* m *if* $m \leq 2n/3$, *each coalition country's exports are increasing in* m *if* $m \leq n/2$, *and each fringe country's imports are increasing in* m.

To derive the impact of a larger coalition on welfare, we rewrite (8) and differentiate it with respect to m:

$$\check{W}_i = \int_0^{\check{y}_i} \left[B_i'(y_i) - p\right] \mathrm{d}y_i + \int_0^{\check{x}_i} \left[p - C_i'(x_i)\right] \mathrm{d}x_i - H_i(\check{x}), \tag{14}$$

$$\frac{\mathrm{d}\check{W}_i}{\mathrm{d}m} = \underbrace{\left[B_i'(\check{y}_i) - p\right]}_{=\tau_i \text{ from (4)}} \frac{\mathrm{d}\check{y}_i}{\mathrm{d}m} + \underbrace{\left[p - C_i'(\check{x}_i)\right]}_{=\chi_i \text{ from (4)}} \frac{\mathrm{d}\check{x}_i}{\mathrm{d}m} - (\check{y}_i - \check{x}_i)\frac{\mathrm{d}p}{\mathrm{d}m} - H_i'(\check{x})\frac{\mathrm{d}\check{x}}{\mathrm{d}m}, \tag{15}$$

where $\frac{\mathrm{d}p}{\mathrm{d}m} = B_f''\frac{\mathrm{d}y_f}{\mathrm{d}m}$ from (4). The border carbon adjustment drives a positive wedge between the marginal benefits and the marginal costs of the representative households in the coalition, such that an increase in national production ceteris paribus increases national welfare in the coalition. Equivalently, the carbon taxes drive a positive wedge between the marginal revenues and the marginal costs of the representative firms, such that an increase in national production ceteris paribus increases national welfare. However, it also reduces national welfare via the increase in global emissions. Finally, the commodity price is decreasing in the coalition size and each fringe [coalition] country imports [exports] the commodity, which improves [worsens] its terms of trade. Furthermore, we prove in Appendix A.1

Proposition 3. *Consider the linear-quadratic specification* (13) *with* $m \leq n-2$.

- *The welfare of each country and global welfare exceeds that in the fully uncooperative solution and is increasing in the coalition size if* $b \geq \underline{b}$ *and* $m \leq n-4$.
- *The welfare difference between a fringe country and a coalition country is increasing in the coalition size.*

A coalition of a given size m is internally stable if no coalition country has an incentive to leave the coalition $\Phi(m) = W_e(m) - W_f(m-1) \geq 0$, and it is externally stable if no fringe country has an incentive to join the coalition $\Phi(m+1) = W_e(m+1) - W_f(m) \leq 0$. In Appendix A.1, we show that $\Phi(m)$ decreases with m for $m \in [4, n-2]$. Furthermore, we show that $\Phi(4) < 0$ for $n \geq 6$, such that no coalition $m \in [4, n-2]$ is internally stable for $n \geq 6$. Furthermore, we prove in Appendix A.1

Proposition 4. *Consider the linear-quadratic specification* (13) *with* $n \geq 6$.

- *Either* $m = 2$ *or* $m = 3$ *are internally and externally stable.* $n \geq 13$ *or* $b \geq \underline{b}$ *and* $n \geq 10$ *are sufficient for* $m = 3$ *being stable.*
- $m = n - 1$ *can be internally and externally stable.* $n \geq 13$ *or* $b \geq \underline{b}$ *and* $n \geq 10$ *are sufficient for* $m = n - 1$ *being unstable.*
- *No other coalition is internally and externally stable.*

From Lemma 1, we know that $m = n - 1$ coincides with the fully cooperative solution. In general, $m = n - 1$ is stable if $n \leq 6$ or if

$$b \leq \bar{b} := \frac{16(n-1)^2}{n^2(n^2 - 8n + 8)} c. \tag{16}$$

From Proposition 2, we know that $\tau_e \geq 0$ and $\chi_e \geq 0$ hold if and only if $b \geq \underline{b}$ and $b \geq \underline{\underline{b}}$ hold, respectively. Figure 1 depicts $\bar{b}, \underline{b}$ and $\underline{\underline{b}}$ in relation to c for different values of n. In general, $\bar{b}$ declines with m whereas $\underline{\underline{b}}$ and $\underline{b}$ increase with m, such that the intersection points are unique. To sum up, $m = n - 1$ can be internally and externally stable, but for $\tau_e \geq 0$ only if $n \in [6, 12]$, and for $\chi_e \geq 0$ only if $n \in [6, 9]$ and $b/c \geq 1/6$.

4 Lobbying

We assume that in each country, the representative firm is represented by a producer lobby that accounts for the influence on the commodity price p and for the lump-sum transfer T_i^x. Consequently, its gross utility is given by

$$U_i(\chi_i) = \begin{cases} pS_i(p - \chi_i) - C_i[S_i(p - \chi_i)] & \text{for } i \in F, \\ pS_i(p - \overline{\chi}_f) - C_i[S_i(p - \overline{\chi}_f)] & \text{for } i \in E. \end{cases} \tag{17}$$

The producer lobby tries to influence both the government's participation decision via political contributions $L_i^1(m)$ and the government's policy for a given participation decision

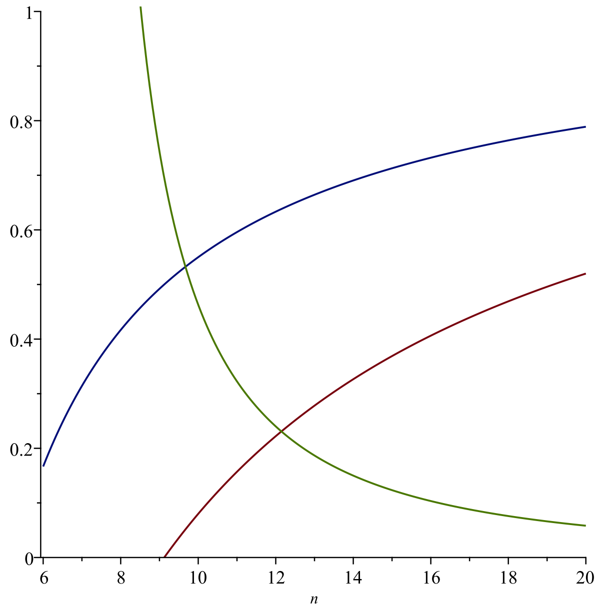

Figure 1: $\overline{b}/c$ (green), $\underline{b}/c$ (blue) and $\underline{\underline{b}}/c$ (red) dependent on n.

$L_i^2(\chi_i)$ (cf. Habla & Winkler (2013)). Consequently, its net utility is given by

$$U_i(\chi_i) - L_i^1(m) - L_i^2(\chi_i). \tag{18}$$

The government's net utility is given by a linear combination of welfare W_i and the political contributions from its producer lobby $L_i^1(m) + L_i^2(\chi_i)$:

$$G_i = W_i(\chi_i) + \mu_i[L_i^1(m) + L_i^2(\chi_i)]. \tag{19}$$

We assume truthful contribution schedules, such that each producer lobby transfers its complete gross utility minus a constant to the government. On the policy stage, this implies

$$L_i^2(\chi_i) = \max[0, U_i(\chi_i) - R_i], \tag{20}$$

with the constant R_i denoting the producer lobby's net utility with lobbying. From (19) and (20), a fringe government's policy maximizes a weighted sum of its welfare and its producer lobby's gross utility

$$\chi_i = \arg\max_{\chi_i}[W_i(\chi_i) + \mu_i U_i(\chi_i)] \qquad \text{for } i \in F, \tag{21}$$

and the coalition's policy maximizes a weighted sum of the coalition countries' welfare and their producer lobbies' gross utility (cf. Marchiori et al. (2017))

$$\chi_e = \arg\max_{\chi_e} \sum_{j \in E}[W_j(\chi_e) + \mu_j U_j(\chi_e)]. \tag{22}$$

In equilibrium, the governments are indifferent whether to accept or reject the contribution payments, which implies

$$W_i(\chi_i) + \mu_i L_i^2(\chi_i) = \check{W}_i, \tag{23}$$

with $\check{W}_i$ denoting the country's welfare without lobbying (cf. Section 3). From (20) and (23), the producer lobby's net utility with lobbying is given by

$$R_i = U_i(\chi_i) - \frac{1}{\mu_i}[\check{W}_i - W_i(\chi_i)] = \check{U}_i + \frac{1}{\mu_i}[W_i(\chi_i) + \mu_i U_i(\chi_i) - \check{W}_i - \mu_i \check{U}_i] > \check{U}_i, \tag{24}$$

with $\check{U}_i$ denoting the producer lobby's net utility without lobbying (cf. Section 3).[4]

On the participation stage, we follow Habla & Winkler (2013) and Marchiori et al. (2017) in assuming that each producer lobby "expects the worst regime to be adopted should it give up lobbying altogether" Marchiori et al. (2017). This implies that a government gets nothing on this stage if it chooses the producer lobby's worse regime, and that it receives the whole producer lobby's net gain if it switches to the other regime, i.e.

$$L_e^1(m) = \max[0, R_e(m) - R_f(m-1)] \quad \text{and} \quad L_f^1(m-1) = \max[0, R_f(m-1) - R_e(m)]. \tag{25}$$

The government participates if and only if

$$\begin{aligned}
& G_e(m) = \check{W}_e(m) + \mu L_e^1(m) > \check{W}_f(m-1) + \mu L_f^1(m-1) = G_f(m-1) \\
\Leftrightarrow \quad & \check{W}_e(m) - \check{W}_f(m-1) + \mu[L_e^1(m) - L_f^1(m-1)] > 0 \\
\Leftrightarrow \quad & \check{W}_e(m) - \check{W}_f(m-1) + \mu[R_e(m) - R_f(m-1)] > 0 \\
\Leftrightarrow \quad & W_e(m) + \mu U_e(m) > W_f(m-1) + \mu U_f(m-1),
\end{aligned} \tag{26}$$

i.e. if the weighted sum of its welfare and its producer lobby's gross utility is greater inside than outside the coalition.

Each fringe country's optimal policy follows from maximizing

$$\begin{aligned}
W_i + \mu_i U_i = {} & B_i[D_i(p)] - C_i[S_i(p-\chi_i)] - H_i\Big[\sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j\Big(p - \chi_e + \tau_e\Big)\Big] \\
& + p[S_i(p-\chi_i) - D_i(p)] + \mu_i\{pS_i(p-\chi_i) - C_i[S_i(p-\chi_i)]\}.
\end{aligned} \tag{27}$$

with respect to its carbon tax subject to $\tau_e = \chi_e - \frac{\sum_{j\in F}\chi_i}{n-m}$ and (7). In Appendix A.1, we solve the maximization problem and find

$$\chi_i = \frac{1}{1+\mu_i}\chi_i|_{\mu=0} + \frac{\mu_i}{1+\mu_i}\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{1}{S_i'}x_i. \tag{28}$$

[4]Since the equilibrium policy maximizes $W_i(\chi_i) + \mu_i U_i(\chi_i)$, the square-bracketed term in (24) is positive.

The lobby group prefers a positive carbon tax ($\mu_i \to \infty \implies \chi_i > 0$) to reduce the commodity supply and, thus, to raise the commodity price. By contrast, it does not account for the climate externality or for the consumer surplus. With symmetric countries, the climate part of $\chi_i|_{\mu=0}$ is positive, whereas the consumer part of $\chi_i|_{\mu=0}$ is definitely negative to raise the commodity supply and, thus, to reduce the commodity price. To sum up, we cannot say whether lobbying increases or decreases the carbon tax, but we can say that an otherwise negative carbon tax can become positive due to lobbying.

The coalition countries' optimal policy follows from maximizing

$$\begin{aligned}\sum_{j\in E} W_j + \sum_{j\in E}\mu_j U_j = &\sum_{j\in E} B_j[D_i(p)] - \sum_{j\in E} C_j[S_j(p-\chi_e)] \\ &- \sum_{j\in E} H_j\Big[\sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j(p-\chi_e+\tau_e)\Big] \\ &+ p\sum_{j\in E}\Big[S_j(p-\chi_e+\tau_e) - D_j(p-\tau_e)\Big] \\ &+ \sum_{j\in E}\mu_j\Big[pS_j(p-\chi_e+\tau_e) - C_j[S_j(p-\chi_e+\tau_e)]\Big],\end{aligned} \tag{29}$$

with respect to their carbon tax subject to $\tau_e = \chi_e - \chi_f$ and (7). In Appendix A.1, we solve the maximization problem and find

$$\chi_e = \chi_e|_{\mu=0} + \frac{\frac{\partial p}{\partial \chi_e}}{1+\frac{\partial p}{\partial \chi_e}} \frac{1}{\sum_{j\in E} D'_j} \sum_{j\in E}\mu_j\Big(x_j + \overline{\chi}_f S'_j\Big). \tag{30}$$

The lobby groups prefer a smaller effective consumption tax (τ_e) to raise the commodity demand and, thus, the commodity price. They definitely prefer a negative effective consumption tax ($\tau_e < 0$) if the fringe countries' carbon taxes (χ_i) are positive, such that their own effective carbon taxes (χ_f) are positive and drive a positive wedge between their marginal revenues and marginal costs. By contrast, if $\chi_f < 0$, the lobby groups can prefer $\tau_e > 0$ to reduce the commodity demand and, thus, the commodity production at negative marginal profits.

To gain further insights into the signs and the magnitudes of the taxes, we now consider the symmetric specification (12) with $\mu_i = \mu\ \forall i \in N$, such that $x_i = x_e$, $y_i = y_e$ for all $i \in E$ and $x_i = x_f$, $y_i = y_f$ for all $i \in F$. Then, substituting (7) into (28) and (30) yields

$$\begin{aligned}\tau_e = &\frac{nm(n-m-1)S'_i[nS'_i - mD'_e - (n-m)D'_f]}{[nS'_i-(n-m)D'_f][(n-m-1)(nS'_i-mD'_e)-(n-m)^2D'_f]}H'_i \\ &- \frac{n\overbrace{[(1-m/n)^2n-1]}^{\geq 0 \Leftrightarrow m/n \leq 1-n^{-0.5}}(nS'_i-mD'_e)-(n-m)^3D'_f}{[nS'_i-(n-m)D'_f][(n-m-1)(nS'_i-mD'_e)-(n-m)^2D'_f]}(y_f-x_f)\end{aligned}$$

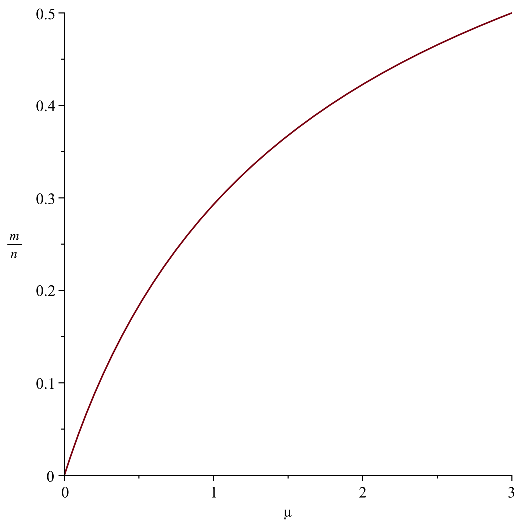

Figure 2: Minimum value of $\frac{m}{n}$ for $\frac{\partial \chi_f}{\partial m}$ to be negative.

Example: $\frac{\partial \chi_f}{\partial m}$ is definitely positive for $\mu = 1$ and $\frac{m}{n} \leq 0.29$.

$$- \frac{m(n-m)[nS_i' - mD_e' - (n-m)D_f']}{[nS_i' - (n-m)D_f'][(n-m-1)(nS_i' - mD_e') - (n-m)^2 D_f']} \mu x_f. \tag{31}$$

Thus, ceteris paribus, lobbying reduces the difference between the carbon taxes. There are three reasons for this result: First, the lobby in e prefers a smaller tax than the government of e, because this reduces τ_e and, thus, increases demand from e and thereby increases the price. (Indeed, it prefers a subsidy.) Second, if the government of f increases its tax, then the lobby in e prefers a decrease in the tax, because this reduces the increase in τ_e and, thus, reduces the demand decrease from e. Third, the lobby in f prefers a positive tax, because this reduces supply from e and f and thereby increases the price.[5] In particular, we prove in ....

Proposition 5. *Consider the linear-quadratic specification* (13) *with* $m \leq n - 2$.

- τ_e *is decreasing in* μ *for* $m \leq 0.8n$ *(sufficient).*
- χ_f *is increasing in* m *for* $m \leq 0.5n$ *and* $\mu \geq 3$ *(sufficient), cf. Figure 2.*

Proposition 5 implies that trade, the consumption difference and the (joint) welfare difference are decreasing in μ for $m \leq 0.8n$ (sufficient):

$$x_e - y_e = \frac{n-m}{m}(y_f - x_f) = \frac{(n-m)\tau_e}{nb}, \quad y_f - y_e = \frac{\tau_e}{b},$$

[5]With the linear-quadratic specification (13), the fractions in (31) are constants, and $y_f - x_f > 0$ increases with τ_e. Suppose $\tau_e|_{\mu>0} \geq \tau_e|_{\mu=0}$ for $m/n \leq 1 - n^{-0.5}$. Then, the right-hand side of (31) would be smaller with lobbying than without, which contradicts $\tau_e|_{\mu>0} \geq \tau_e|_{\mu=0}$. Thus, $\tau_e|_{\mu>0} < \tau_e|_{\mu=0}$ for $m/n \leq 1 - n^{-0.5}$.

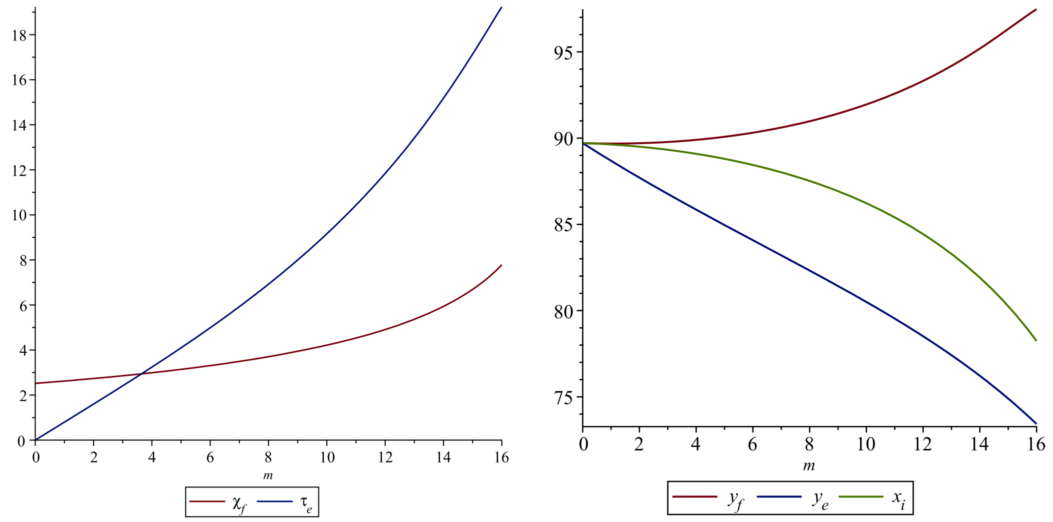

Figure 3: Taxes (left panel) and quantities (right panel).

$$W_f + \mu U_f - W_e - \mu U_e = W_f - W_e = \frac{\tau_e^2}{2b}.$$

We find that coalitions $m \in [4, n-2]$ can be stable. In particular, for $n = 20$, $\mu = 2/3$, $a = 164$, $b = 0.8$, $c = 1$, $h = 5$, the coalition $m = 8$ is stable. For this numerical example, Figure 3 depicts the taxes and quantities depending on the coalition size, and Figure 4 depicts the joint welfares of each country and its lobby group as well as the internal and external stability conditions. Finally, Figure 5 depicts the differences in global emissions and global welfare with and without lobbying. Global emissions are larger and global welfare is smaller with lobbying than without for a given coalition size. However, the coalition is larger with lobbying than without, such that global emissions are smaller (2%) and global welfare is larger (10%) in the coalition-fringe equilibrium with lobbying than in the equilibrium without.

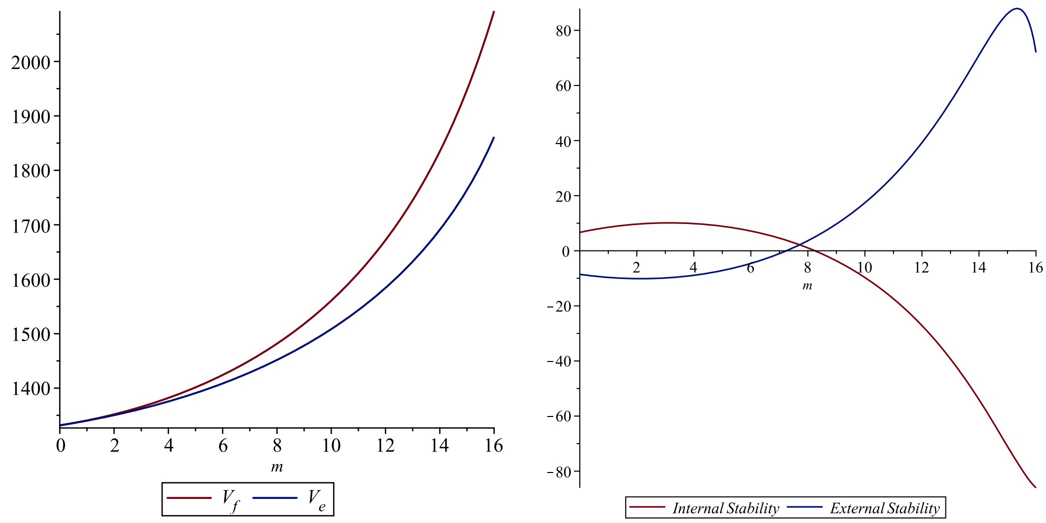

Figure 4: Joint welfares (left panel) and stability conditions (right panel).

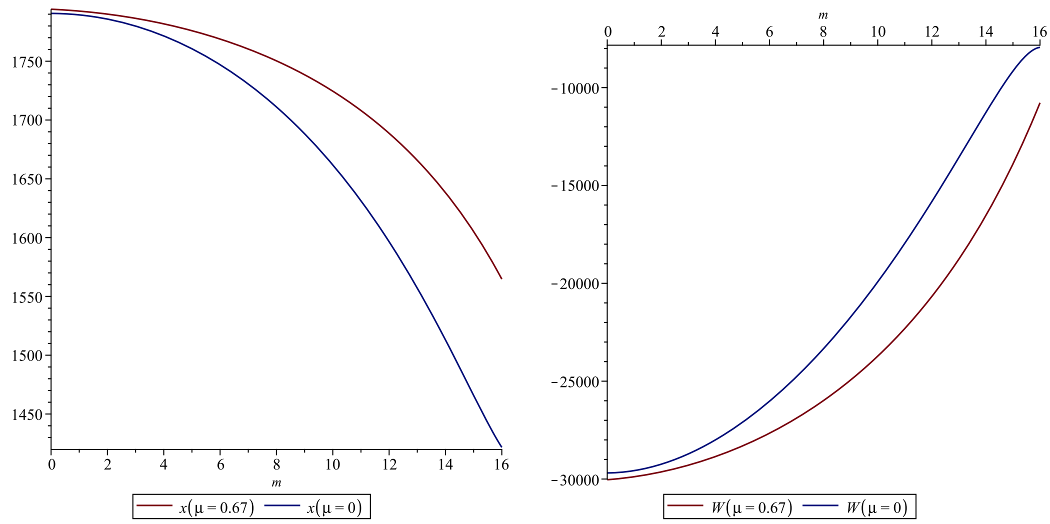

Figure 5: Global emissions (left panel) and global welfare (right panel) with and without lobbying.

5 Lobbying without border carbon adjustment

Each fringe country's optimal policy follows from maximizing

$$W_i = B_i[D_i(p)] - C_i[S_i(p-\chi_i)] - H_i\Big[\sum_{j\in N} S_j(p-\chi_j)\Big] + p[S_i(p-\chi_i) - D_i(p)] \\ + \mu_i\{pS_i(p-\chi_i) - C_i[S_i(p-\chi_i)]\}, \tag{32}$$

with respect to its carbon tax subject (7). In Appendix A.3, we solve the maximization problem and find

$$\chi_i = \frac{1}{1+\mu_i}\Big\{H_i' - \underbrace{\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{\sum_{j\in N\setminus i} S_j'}{S_i'}H_i'}_{CL_i} + \underbrace{\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{1}{S_i'}(x_i-y_i)}_{ToT_i}\Big\} + \frac{\mu_i}{1+\mu_i}\frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{1}{S_i'}x_i \\ = -\frac{D'H_i' - (x_i-y_i)}{\sum_{j\in N\setminus i} S_j' - D'} + \frac{\mu_i}{1+\mu_i}\frac{D'H_i' + y_i}{\sum_{j\in N\setminus i} S_j' - D'}. \tag{33}$$

Thus, the carbon tax accounts for the fringe country's climate externality on itself (H_i'), but also for the increase in foreign emissions (CL_i) and for the increase in its export revenues or import costs (ToT_i) induced by the decrease in its commodity supply and, thus, the increase in the commodity price. The lobby group prefers a positive carbon tax ($\mu_i \to \infty \implies \chi_i > 0$) to reduce the commodity supply and, thus, to raise the commodity price. Furthermore, ceteris paribus, lobbying increases the carbon tax if and only if $H_i' < \frac{y_i}{|D'|}$, i.e. if and only if the marginal climate costs are sufficiently small.

The coalition countries' optimal policy follows from maximizing

$$\sum_{j\in E} W_j = \sum_{j\in E} B_j[D_i(p)] - \sum_{j\in E} C_j[S_j(p-\chi_e)] - \sum_{j\in E} H_j\Big[\sum_{j\in N} S_j(p-\chi_e)\Big] \\ + p\sum_{j\in E}[S_j(p-\chi_e) - D_j(p)], \tag{34}$$

with respect to their carbon tax subject to (7). In Appendix A.3, we solve the maximization problem and find

$$\chi_e = \frac{\sum_{j\in E} S_j'}{\sum_{j\in E}(1+\mu_j)S_j'}\Big\{\sum_{j\in E} H_j' - \underbrace{\frac{\frac{\partial p}{\partial \chi_e}}{1-\frac{\partial p}{\partial \chi_e}}\frac{\sum_{j\in F} S_j'}{\sum_{j\in E} S_j'}\sum_{j\in E} H_j'}_{CL_e} - \underbrace{\frac{\frac{\partial p}{\partial \chi_e}}{1-\frac{\partial p}{\partial \chi_e}}\frac{1}{\sum_{j\in E} S_j'}\sum_{j\in E}(y_j - x_j)}_{ToT_e}\Big\} \\ - \frac{\sum_{j\in E} S_j'}{\sum_{j\in E}(1+\mu_j)S_j'}\frac{\frac{\partial p}{\partial \chi_e}}{1-\frac{\partial p}{\partial \chi_e}}\frac{\sum_{j\in E}}{\sum_{j\in E} S_j'}\mu_j x_j \\ = -\frac{\sum_{j\in E} S_j'}{\sum_{j\in E}(1+\mu_j)S_j'}\frac{\sum_{j\in E}[D'H_j' + (y_j - x_j)]}{\sum_{j\in F} S_j' - D'} - \frac{\sum_{j\in E} S_j'}{\sum_{j\in E}(1+\mu_j)S_j'}\frac{\sum_{j\in E}\mu_j x_j}{\sum_{j\in F} S_j' - D'}. \tag{35}$$

Thus, the coalition's carbon tax consists of the same parts as the fringe's carbon tax. Furthermore, ceteris paribus, lobbying increases the carbon tax for $\mu_i = \mu$ if and only if $\sum_{j\in E} H'_j < \frac{\sum_{j\in E} y_j}{|D'|}$, i.e. if and only if the marginal climate costs are sufficiently small.

To gain further insights into the signs and the magnitudes of the taxes, we now consider the symmetric specification (12) with $\mu_i = \mu \; \forall i \in N$, such that $x_i = x_e$, $y_i = y_e$ for all $i \in E$ and $x_i = x_f$, $y_i = y_f$ for all $i \in F$. For later reference, we prove in Appendix A.3

Lemma 2. *Consider the symmetric specification* (12) *with* $m = 1$ *and suppose* $C'''_i \leq 0$. *Then,* $\chi_e = \chi_f = \frac{1}{1+\mu}\frac{\mu x_i - D' H'_i}{S' - S'_i - D'}$ *and* $y_e = y_f = x_e = x_f$ *is the coalition-fringe equilibrium without border carbon adjustment, which coincides with the fully uncooperative solution.*

With symmetric countries, substituting (7) into (33) and (35) yields

$$\begin{aligned}
\chi_e - \chi_f = &-\frac{m^2 S'_e + [(m-1)(n-m-1)-1]S'_f - (m-1)D'}{[(n-m)S'_f - D'][S' - S'_f - D']} D' H'_i \\
&- \frac{(n-m)S' - (n-m+1)D'}{[(n-m)S'_f - D'][S' - S'_f - D']}(x_f - y_f) \\
&+ \frac{\mu}{1+\mu}\frac{m^2 S'_e + [(m-1)(n-m-1)-1]S'_f - (m-1)D'}{[(n-m)S'_f - D'][S' - S'_f - D']}[D' H'_i + y_i]. \qquad (36)
\end{aligned}$$

Thus, ceteris paribus, lobbying increases the difference between the carbon taxes for $m \in [2, n-2]$ if and only if $H'_i < \frac{y_i}{|D'|}$, i.e. if and only if it increases the fringe's carbon tax and the coalition's carbon tax.

Indicating the coalition-fringe equilibrium without border carbon adjustment by a tilde, we prove in Appendix A.3

Proposition 6. *Consider the symmetric specification* (12) *with* $m > 1$.

- *For* $C'''_i \leq 0$, *we find* $\tilde{\chi}_e > \tilde{\chi}_f > 0$, $\tilde{y}_e = \tilde{y}_f$, $\tilde{x}_e < \tilde{x}_f$ *and* $\tilde{W}_e < \tilde{W}_f$.
- *For* $C'''_i \leq 0$ *and* $B'''_i \geq 0$, *we find* $\tilde{\chi}_f < \chi^*_i$, $\tilde{y}_e = \tilde{y}_f > y^*_i$ *and* $\tilde{x}_f > x^*_i$. *For* $C'''_i \leq 0$ *and* $B'''_i = H''_i = 0$, *we find* $\tilde{\chi}_e < \chi^*_i$.
- *For* $C'''_i = B'''_i = 0$, *we find* $\tilde{\chi}_e > \chi^\circ_i$, $\tilde{y}_e = \tilde{y}_f < y^\circ_i$ *and* $\tilde{x}_e < x^\circ_i$. *For* $C'''_i = B'''_i = H'' = 0$, *we find* $\tilde{\chi}_f > \chi^\circ_i$.

Since the countries are symmetric and consumption is not taxed, consumption of the countries coincides. The stronger internalization of the climate externality implies a greater carbon tax in the coalition countries than in the fringe countries, such that production of the fringe countries exceeds that of the coalition countries, and the fringe countries export the commodity. Then, the environmental part ($H'_i + CL_i$) and the terms-of-trade part (ToT_i)

of (33) are positive, such that the carbon tax of the fringe countries is positive. Since the consumer surpluses and the climate damages of the countries coincide but the fringe countries' producer surpluses exceed those of the coalition countries, the welfare of each fringe country exceeds that of each coalition country.

Compared to the fully cooperative solution, the climate externality is underinternalized, such that consumption exceeds that in the fully cooperative solution. Consequently, at least the fringe countries face a smaller carbon tax and produce more than in the fully cooperative solution. By contrast, consumption falls short of that in the fully uncooperative solution. Consequently, at least the coalition countries face a greater carbon tax and produce less than in the fully uncooperative solution.

To derive the impact of a larger coalition on the allocation and on welfare, we now consider the linear-quadratic specification (13). Then, we prove in Appendix A.3

Proposition 7. *Consider the linear-quadratic specification* (13) *with* $m > 1$.

- $\tilde{\chi}_e$, $\tilde{\chi}_f$ *and* $\tilde{\chi}_e - \tilde{\chi}_f$ *are increasing in* m.
- *Each country's consumption* ($y_i^\circ > \tilde{y}_i > y_i^*$) *is decreasing in* m.
- *Each coalition country's production* ($x_i^\circ > \tilde{x}_e > x_i^*$) *is decreasing in* m, *and each fringe country's production* ($\tilde{x}_f > x_i^\circ > x_i^*$) *is increasing in* m.
- *Total trade and each coalition country's imports are increasing in* m *if* $m \leq (n+1)/2$, *and each fringe country's exports are increasing in* m.

The larger the coalition, the more it internalizes the climate externality and, thus, the greater is its carbon tax and the smaller is its commodity production. This raises the commodity price, which increases each fringe country's production and exports. Consequently, each fringe country's carbon tax increases to improve its terms-of-trade. Since all carbon taxes are increasing in the coalition size, each country's consumption and, thus, global emissions are decreasing in the coalition size.

To derive the impact of a larger coalition on welfare, we rewrite (8) and differentiate it with respect to m:

$$\tilde{W}_i = \int_0^{\tilde{y}_i} \left[B_i'(y_i) - p\right] \mathrm{d}y_i + \int_0^{\tilde{x}_i} \left[p - C_i'(x_i)\right] \mathrm{d}x_i - H_i(\tilde{x}), \tag{37}$$

$$\frac{\mathrm{d}\tilde{W}_i}{\mathrm{d}m} = \underbrace{\left[B_i'(\tilde{y}_i) - p\right]}_{=0 \text{ from (4)}} \frac{\mathrm{d}\tilde{y}_i}{\mathrm{d}m} + \underbrace{\left[p - C_i'(\tilde{x}_i)\right]}_{=\chi_i \text{ from (4)}} \frac{\mathrm{d}\tilde{x}_i}{\mathrm{d}m} - (\tilde{y}_i - \tilde{x}_i)\frac{\mathrm{d}p}{\mathrm{d}m} - H_i'(\tilde{x})\frac{\mathrm{d}\tilde{x}}{\mathrm{d}m}, \tag{38}$$

where $\frac{\mathrm{d}p}{\mathrm{d}m} = B_i''\frac{\mathrm{d}y_i}{\mathrm{d}m}$ from (4). Global emissions are decreasing in the coalition size, which increases the welfare of each country by the same amount. The carbon taxes drive a positive wedge between the marginal profits and the marginal costs of the representative firms, such that an increase in national production increases national welfare. From Proposition (7), we know that each fringe [coalition] country's production is increasing [decreasing] in the coalition size. Furthermore, the commodity price is increasing in the coalition size and each fringe [coalition] country exports [imports] the commodity, which improves [worsens] its terms of trade. Consequently, the wedge between the welfare of a fringe country and that of a coalition country is increasing in the coalition size. Furthermore, we prove in Appendix A.3

PROPOSITION 8. *Consider the linear-quadratic specification* (13) *with* $m > 1$.

- *The welfare of each fringe country exceeds that in the fully uncooperative solution and is increasing in the coalition size.*
- *The joint welfare of each country and the joint global welfare exceeds that in the fully uncooperative solution and is increasing in the coalition size.*
- *The (joint) welfare difference between a fringe country and a coalition country is increasing in the coalition size.*

Thus, global emissions being decreasing in the coalition size outweighs the negative welfare consequences of a larger coalition for the joint welfare of each coalition country, and increases the joint global welfare despite the increasing wedge between the joint welfare of a fringe country and that of a coalition country. From Lemma 2, we know that the coalition-fringe equilibrium without border carbon adjustment coincides with the fully uncooperative solution for $m = 1$, such that the joint welfare of each country being increasing in the coalition size implies that the joint welfare of each country and, thus, the joint global welfare exceeds that in the fully uncooperative solution for $m > 1$.

Defining

$$\bar{a} := nh + \frac{n^3 c(b+c)h}{b[(n-m-1)(n-m)b + n^2 c]} \quad \text{with} \quad \tfrac{\partial \bar{a}}{\partial h}, \tfrac{\partial \bar{a}}{\partial m}, b\tfrac{\partial \bar{a}}{\partial c} = -c\tfrac{\partial \bar{a}}{\partial b} > 0, \tag{39}$$

we prove in Appendix ...

PROPOSITION 9. *Consider the linear-quadratic specification* (13).

If and only if $a > \bar{a}$, *then*

- $\tilde{\chi}_e$, $\tilde{\chi}_f$ *and* $\tilde{\chi}_e - \tilde{\chi}_f$ *are increasing in* μ.
- *Each country's consumption is decreasing in* μ.

- *Each coalition country's production is decreasing in μ, and $\tilde{x}_f - \tilde{x}_e$ is increasing in μ.*
- *Each country's trade is increasing in μ.*
- *The welfare difference between a fringe country and a coalition country is increasing in μ.*

If $a \leq \bar{a}$, then the welfare of each coalition country and global welfare is decreasing in μ. If $a \geq \bar{a}$, then the joint welfare difference between a fringe country and a coalition country is increasing in μ.

For $a > \bar{a}$, the marginal climate costs are so small that the lobby groups prefer higher carbon taxes than their governments. Thus, lobbying raises the taxes and reduces global consumption and production. However, the impact of lobbying is stronger in the coalition countries than in the fringe countries, such that production decreases more in the former than in the latter. Consequently, lobbying reduces the trade volume and increases the welfare difference between the coalition countries and the fringe countries. The opposite is true for $a < \bar{a}$, but $a < \bar{a}$ also implies that lobbying reduces the internalization of the climate externality and, thus, the welfare of each coalition country as well as global welfare. Finally, lobbying does not only increase the welfare difference but also the joint welfare difference between the coalition countries and the fringe countries for $a > \bar{a}$, which raises the free-rider incentives.

A coalition of a given size m is internally stable if no coalition country has an incentive to leave the coalition $\Phi(m) = W_e(m) + \mu U_e(m) - W_f(m-1) - \mu U_f(m-1) \geq 0$, and it is externally stable if no fringe country has an incentive to join the coalition $\Phi(m+1) = W_e(m+1) + \mu U_e(m+1) - W_f(m) - \mu U_f(m) \leq 0$. In Appendix A.3, we show that $\Phi(m)$ decreases with m for $m \in [4, n-2]$. Furthermore, we show that $\Phi(4) < 0$ for $n \geq 7$, such that no coalition $m \in [4, n-2]$ is internally stable for $n \geq 7$. Furthermore, we prove in Appendix A.3

Proposition 10. *Consider the linear-quadratic specification* (13) *with $n \geq 7$.*

- *$m = 3$ is internally and externally stable.*
- *$m = n$ can be internally stable. The condition for $m = n$ being stable becomes stricter when μ increases.*
- *No other coalition is internally and externally stable.*

In general, $m = n$ is stable if and only if

$$\begin{aligned} & b \geq \frac{n^2(n-3)}{4(n-1)}c + \frac{\mu}{1+\mu}\frac{(n-2)(n^2-n+2)}{4(n-1)}\frac{bc}{b+c} \\ \Leftrightarrow \quad & b \geq \frac{n^2(n-3)}{4(n-1)}c + \mu\frac{n^2(n-2)(n-3)(n^2-n+2)}{2(n-1)\Xi}c. \end{aligned} \tag{40}$$

where

$$\Xi := (n-2)(n^2-n+2) + \sqrt{(n-2)(n^2-n+2)[4(n-1)+(2\mu+1)^2n^2(n-3)]} > 0.$$

6 Conclusion

We have studied the influence of producer lobbies on climate policies and coalition formation with BCA in a partial equilibrium model with international trade. Countries use carbon taxes to regulate carbon emissions and the climate coalition uses BCA to reduce carbon leakage. Our findings highlight a novel mechanism that has the potential to stabilize large climate coalitions. Lobbies in fringe countries prefer positive taxes to increase the price by reducing supply in their countries and, through the effect of BCA, in the coalition countries. In coalition countries, lobbies prefer a carbon subsidy to effectively increase demand, which again increases the price. Thus, lobbying in all countries ceteris paribus reduces the tax and welfare differences between members and outsiders of a coalition and thereby the free-rider incentives. As a result, larger coalitions can be stable.

As the introduction of BCA raises on the political agenda, our findings are highly relevant for policymakers considering the pros and cons of BCA. We reveal a channel through which the political distortion of nationally welfare maximizing governments in case of protection of exposed industries through BCA can lead to a globally improved situation, which might seem counterintuitive at first sight. In this case, "green protection for sale" turns into environmental protection.

A Appendix

A.1 Proofs of Section 3

For $\phi = 1$, the joint welfare of a fringe country and its lobby group is given by

$$U_i = B_i[D_i(p)] - C_i[S_i(p-\chi_i)] - H_i\Big[\sum_{j\in F} S_j(p-\chi_j) + \sum_{j\in E} S_j\Big(p - \frac{\sum_{j\in F}\chi_i}{n-m}\Big)\Big]$$
$$+ p[S_i(p-\chi_i) - D_i(p)] + \mu_i\{pS_i(p-\chi_i) - C_i[S_i(p-\chi_i)]\}. \quad (A.1)$$

The first-order condition with respect to χ_i reads

$$0 = -[p - C_i' - H_i']S_i' + \frac{H_i'\sum_{j\in E} S_j'}{n-m} + \Big\{[B_i' - p]D_i' + [p - C_i']S_i' - H_i'\sum_{j\in N} S_j' + x_i - y_i\Big\}\tfrac{\partial p}{\partial \chi_i}$$
$$+ \mu\Big\{-[p - C_i']S_i' + [[p - C_i']S_i' + x_i]\tfrac{\partial p}{\partial \chi_i}\Big\}. \quad (A.2)$$

Substituting (4) for $i \in F$ and rearranging yields

$$0 = -[(1+\mu_i)\chi_i - H_i']S_i' + \frac{H_i'\sum_{j\in E} S_j'}{n-m}$$
$$+ \Big[(1+\mu_i)\chi_i S_i' - H_i'\sum_{j\in N} S_j' + (1+\mu_i)x_i - y_i\Big]\tfrac{\partial p}{\partial \chi_i} \quad (A.3)$$
$$\Leftrightarrow \chi_i = \frac{1}{1+\mu_i}\Big\{H_i' + \frac{1}{1-\frac{\partial p}{\partial \chi_i}}\frac{\sum_{j\in E} S_j'}{(n-m)S_i'}H_i' - \frac{\frac{\partial p}{\partial \chi_i}}{1-\frac{\partial p}{\partial \chi_i}}\frac{1}{S_i'}\Big[\sum_{j\in N\setminus i} S_j' H_i' + y_i - (1+\mu_i)x_i\Big]\Big\}. \quad (A.4)$$

For $\phi = 1$, the joint welfare of the coalition countries and their lobby groups is given by

$$\sum_{j\in E} U_j = \sum_{j\in E} B_j[D_j(p+\chi_e-\chi_f)] - \sum_{j\in E} C_j[S_j(p-\chi_f)]$$
$$- \sum_{j\in E} H_j\Big[\sum_{j\in E} S_j(p-\chi_f) + \sum_{j\in F} S_j(p-\chi_j)\Big]$$
$$+ p\sum_{j\in E}\Big[S_j(p-\chi_f) - D_j(p+\chi_e-\chi_f)\Big]$$
$$+ \sum_{j\in E}\mu_j\Big[pS_j(p-\chi_f) - C_j[S_j(p-\chi_f)]\Big], \quad (A.5)$$

The first-order condition with respect to χ_e reads

$$0 = \sum_{j\in E}[B_j' - p]D_j' + \sum_{j\in E}\Big\{[B_j' - p]D_j' + [p - C_j']S_j' - H_j'\sum_{j\in N} S_j' + x_j - y_j\Big\}\tfrac{\partial p}{\partial \chi_e}$$
$$+ \sum_{j\in E}\mu_j\{[p - C_j']S_j' + x_j\}\tfrac{\partial p}{\partial \chi_e}. \quad (A.6)$$

Substituting (4) for $i \in E$ and rearranging yields

$$
\begin{aligned}
0 &= (\chi_e - \chi_f) \sum_{j \in E} D'_j \Big(1 + \tfrac{\partial p}{\partial \chi_e}\Big) \\
&\quad + \sum_{j \in E} \Big[(1+\mu_j)\chi_f S'_j - H'_j \sum_{j \in N} S'_j + (1+\mu_j)x_j - y_j\Big] \tfrac{\partial p}{\partial \chi_e} \qquad \text{(A.7)}
\end{aligned}
$$

$$
\Leftrightarrow \ \chi_e = \chi_f - \frac{\frac{\partial p}{\partial \chi_e}}{1 + \frac{\partial p}{\partial \chi_e}} \frac{1}{\sum_{j \in E} D'_j} \sum_{j \in E} \Big[(1+\mu_j)\chi_f S'_j - H'_j \sum_{j \in N} S'_j + (1+\mu_j)x_j - y_j\Big]. \qquad \text{(A.8)}
$$

Proof of Lemma 1. Consider the symmetric specification (12) with $m = n - 1$. Then, substituting (7) into (A.4) and (A.8) yields

$$
\chi_f = \frac{1}{1+\mu} n H'_i - \frac{1}{1+\mu} \frac{nS'_i - (n-1)D'_e}{-S'_i D'_f} \Big[y_f - (1+\mu)x_f\Big], \qquad \text{(A.9)}
$$

$$
\chi_e = \chi_f - \frac{n-1}{nS'_i - D'_f} \Big[(1+\mu)\chi_f S'_i - nH'_i S'_i + (1+\mu)x_e - y_e\Big]. \qquad \text{(A.10)}
$$

Using $m(y_e - x_e) = (n - m)(x_f - y_f)$, we get

$$
\chi_e - \chi_f = \frac{(n-1)(S' - D') + nD'_f}{-(S' - D'_f)D'_f}(y_f - x_f) - \frac{(n-1)(S' - D')}{-(S' - D'_f)D'_f} \mu x_f. \qquad \text{(A.11)}
$$

For $\mu = 0$, $\chi_e = \chi_f$ implies $y_f = x_f$ and, thus, $y_e = y_f$, which in turn implies $\chi_e = \chi_f$. Thus, $\chi_e = \chi_f$ is an equilibrium for $\mu = 0$. For $\mu > 0$, $\chi_e = \chi_f$ implies $y_f \neq x_f$ and, thus, $y_e \neq y_f$, which in turn implies $\chi_e \neq \chi_f$. Thus, $\chi_e = \chi_f$ cannot be an equilibrium for $\mu > 0$. □

Proof of Proposition 1. Consider the symmetric specification (12). Then, substituting (7) into (A.4) and (A.8) yields

$$
\begin{aligned}
\chi_f &= -\frac{1}{1+\mu} \frac{n(n-m)D'_f}{(n-m-1)[nS'_i - mD'_e] - (n-m)^2 D'_f} H'_i \\
&\quad - \frac{1}{1+\mu} \frac{nS'_i - mD'_e}{S'_i[(n-m-1)[nS'_i - mD'_e] - (n-m)^2 D'_f]} \Big[y_f - (1+\mu)x_f\Big], \qquad \text{(A.12)}
\end{aligned}
$$

$$
\chi_e = \chi_f - \frac{m}{nS'_i - (n-m)D'_f} \Big[(1+\mu)\chi_f S'_i - nH'_i S'_i + (1+\mu)x_e - y_e\Big]. \qquad \text{(A.13)}
$$

Using $m(y_e - x_e) = (n - m)(x_f - y_f)$, we get

$$
\begin{aligned}
\chi_e - \chi_f &= \frac{nm(n-m-1)S'_i[nS'_i - mD'_e - (n-m)D'_f]}{[nS'_i - (n-m)D'_f][(n-m-1)(nS'_i - mD'_e) - (n-m)^2 D'_f]} H'_i \\
&\quad - \frac{n \overbrace{[(1-m/n)^2 n - 1]}^{\geq 0 \Leftrightarrow m/n \leq 1 - n^{-0.5}} (nS'_i - mD'_e) - (n-m)^3 D'_f}{[nS'_i - (n-m)D'_f][(n-m-1)(nS'_i - mD'_e) - (n-m)^2 D'_f]} (y_f - x_f) \\
&\quad - \frac{m(n-m)[nS'_i - mD'_e - (n-m)D'_f]}{[nS'_i - (n-m)D'_f][(n-m-1)(nS'_i - mD'_e) - (n-m)^2 D'_f]} \mu x_f. \qquad \text{(A.14)}
\end{aligned}
$$

Suppose $\chi_e \leq \chi_f$, such that $y_e \geq y_f$ and $y_f - x_f \leq 0$ hold, and suppose $m/n \leq 1 - n^{-0.5}$ and $\mu = 0$. Then, the first line and the second line of (A.14) are positive, and the third line of (A.14) is zero, which contradicts $\chi_e \leq \chi_f$. Thus, $\chi_e > \chi_f$ for $m/n \leq 1 - n^{-0.5}$ and $\mu = 0$. From (8), we get

$$\check{W}_i = \int_0^{\check{y}_i} \left[B_i'(y_i) - p\right] \mathrm{d}y_i + \int_0^{\check{x}_i} \left[p - C_i'(x_i)\right] \mathrm{d}x_i - H_i(\check{x}), \tag{A.15}$$

$$\check{W}_f - \check{W}_e = \int_{\check{y}_e}^{\check{y}_f} \left[B_i'(y_i) - p\right] \mathrm{d}y_i. \tag{A.16}$$

Since consumption is not subsidized, i.e. $B_i'(y_i) - p = \tau_i \geq 0$ for all $y_i \in [0, \check{y}_i]$, a fringe country's consumer surplus and, thus, welfare exceeds that of a coalition country. □

Consider the linear-quadratic specification (13). Then, the equilibrium with arbitrary carbon taxes and $\phi \geq 0$ is characterized by

$$a - by_e - \phi(\chi_e - \chi_f) = a - by_f, \tag{A.17a}$$

$$a - by_e = cx_e + \chi_e, \tag{A.17b}$$

$$a - by_f = cx_f + \chi_f, \tag{A.17c}$$

$$my_e + (n-m)y_f = mx_e + (n-m)x_f. \tag{A.17d}$$

Solving for y_i and x_i yields

$$y_i = \frac{a - \chi_i}{b+c} + \frac{c}{b+c} \cdot (y_i - x_i), \tag{A.18a}$$

$$x_i = \frac{a - \chi_i}{b+c} - \frac{b}{b+c} \cdot (y_i - x_i), \tag{A.18b}$$

$$x = \frac{na - m\chi_e - (n-m)\chi_f}{b+c}, \tag{A.18c}$$

where

$$(y_e - x_e) = \frac{(n-m)(\chi_e - \chi_f)[b - \phi(b+c)]}{nbc}, \tag{A.19}$$

$$(y_f - x_f) = -\frac{m(\chi_e - \chi_f)[b - \phi(b+c)]}{nbc}. \tag{A.20}$$

Substituting (13) into (A.12) and (A.13) yields

$$\chi_f = \frac{1}{1+\mu} \frac{cn(n-m)h}{n(n-m-1)(b+c) + (n-m)c} - \frac{1}{1+\mu} \frac{c(bn+cm)(y_f - (1+\mu)x_f)}{n(n-m-1)(b+c) + (n-m)c}, \tag{A.21}$$

$$\chi_e = \chi_f - \frac{mb((1+\mu)\chi_f - hn + c((1+\mu)x_e - y_e))}{nb + (n-m)c}. \tag{A.22}$$

Using (A.18), (A.19) and (A.20), solving (A.21) and (A.22) for χ_f and χ_e for $\mu = 0$ and $\phi = 1$ yields

$$\chi_f = \frac{n(n^2 - m^2 - mn)ch}{\Gamma}, \tag{A.23}$$

$$\chi_e = \frac{m[n^2(n-m-1)b + (n^2 - m^2 - mn)/mc]h}{\Gamma}, \tag{A.24}$$

and

$$\chi_e - \chi_f = \frac{n^2 m(n-m-1)bh}{\Gamma}, \tag{A.25}$$

where

$$\Gamma := n^2(n-m-1)b + [(n+m)(n-m)^2 - nm]c, \tag{A.26}$$

$$\frac{\partial \Gamma}{\partial m} = -n^2 b - [(n+3m+1)(n-m) + m]c < 0. \tag{A.27}$$

Proof of Proposition 2. $\chi_e - \chi_f$ is positive if and only if Γ is positive. Since $\frac{\partial \Gamma}{\partial m} < 0$, Γ is positive for all $m \leq n-2$ if and only if it is positive for $m = n-2$. From (A.26), this is the case if and only if $b > \underline{\underline{b}} := \frac{n^2-10n+8}{n^2}c$. $\underline{\underline{b}}$ increases with n, is smaller than c and negative for $n \leq 9$. From (A.23), χ_f is positive if and only if $n^2 - m^2 - mn > 0$, which is the case if and only if $m/n < \frac{2}{1+\sqrt{5}} \approx 0.62$. From (A.24), χ_e is negative if and only if $n^2(n-m-1)b + (n^2 - m^2 - mn)/mc$ is negative. Since this term decreases with m, χ_e is positive for all $m \leq n-2$ if and only if it is positive for $m = n-2$. This is the case if and only if $b > \underline{b} := \frac{n^2-6n+4}{n(n-2)}c$. $\underline{b}$ increases with n, is smaller than c and negative for $n \leq 5$. Furthermore, $\underline{b} - \underline{\underline{b}} = \frac{6n^2-24n+16}{n^2(n-2)}$ is positive for $n \geq 4$. Differentiating (A.23) and (A.25) with respect to m yields

$$\begin{aligned}
\frac{\partial \check{\chi}_f}{\partial m} = & -\frac{n^3[(2m-1)M_2 + m^2 + m - 2](b - \underline{b})ch}{\Gamma^2} - \frac{2n(m-1)M_2^4 c^2 h}{(n-2)\Gamma^2} \\
& - \frac{n[(10m^2 - 6m - 8)M_2^3 + (16m^3 + 5m^2 - 40m - 4)M_2^2]c^2 h}{(n-2)\Gamma^2} \\
& - \frac{n(9m^4 + 16m^3 - 38m^2 - 40m + 16)M_2 c^2 h}{(n-2)\Gamma^2} \\
& - \frac{n(m-2)(m+1)(m^3 + 8m^2 + 4m - 8)c^2 h}{(n-2)\Gamma^2} < 0 \Leftarrow \check{\chi}_e \geq 0,
\end{aligned} \tag{A.28}$$

$$\begin{aligned}
\frac{\partial(\check{\chi}_e - \check{\chi}_f)}{\partial m} = & \frac{n^4(n-m-1)^2 b^2 h + n^2[M_2^4 + (2m+7)M_2^3 + (2m^2 + 9m + 18)M_2^2]bch}{\Gamma^2} \\
& + \frac{n^2[(5m^2 + 12m + 20)M_2 + (m+2)(m^2+4)]bch}{\Gamma^2} > 0,
\end{aligned} \tag{A.29}$$

where $M_i := n - m - i$. This proves the first bullet of the proposition.

Substituting (A.23) and (A.24) into (A.18), (A.19) and (A.20) yields

$$\begin{aligned}\check{y}_e &= \frac{a-nh}{b+c} + \frac{n^2(n-m)(n-m-1)h}{\Gamma} > y_i^* \\ &= \frac{a(n-1)b+cn(a-h)}{[(n-1)b+nc](b+c)} - \frac{m(n-1)[n^2(n-m-1)b+(n^2-m^2-mn)/mc]h}{[(n-1)b+nc]\Gamma} \\ &\quad - \frac{n(n-1)(n-m)(n-m-1)(m-2+(n-2)/(n-1))ch}{[(n-1)b+nc]\Gamma} < y_i^\circ \Leftarrow \check{\chi}_e \ge 0, \quad \text{(A.30a)}\end{aligned}$$

$$\check{y}_f = \frac{a(n-1)b+cn(a-h)}{[(n-1)b+nc](b+c)} + \frac{nm[mN_2^2+(m^2+3m-1)N_2+2m^2+m-2]ch}{[(n-1)b+nc]\Gamma} > y_i^\circ, \tag{A.30b}$$

$$\begin{aligned}\check{x}_i &= \frac{a-nh}{b+c} + \frac{n(n-m-1)(n-m)(n+m)h}{\Gamma} > x_i^* \\ &= \frac{a(n-1)b+cn(a-h)}{[(n-1)b+nc](b+c)} - \frac{nm^2(n-1)(n-2)(n-m-1)(b-\underline{b})h}{(n-2)[(n-1)b+nc]\Gamma} \\ &\quad - \frac{m[mM_4^4+(3m^2+8m+1)M_4^3+(3m^3+18m^2+20m+10)M_4^2]ch}{(n-2)[(n-1)b+nc]\Gamma} \\ &\quad - \frac{m[(m^4+12m^3+29m^2+14m+32)M_4+2m^4+10m^3+8m^2-4m+32]ch}{(n-2)[(n-1)b+nc]\Gamma} \\ &\quad < x_i^\circ \Leftarrow b \ge \underline{b}, M_4 \ge 0. \quad \text{(A.30c)}\end{aligned}$$

Substituting (A.23) and (A.24) into (A.18), (A.19) and (A.20), and differentiating with respect to m yields

$$\begin{aligned}\frac{\partial \check{y}_e}{\partial m} &= -\frac{n^4(n-2)(n-m-1)^2(b-\underline{b})h}{(n-2)\Gamma^2} - \frac{n^2[2M_4^5+(4m+29)M_4^4]ch}{(n-2)\Gamma^2} \\ &\quad - \frac{n^2[(3m^2+44m+164)M_4^3+(m^3+21m^2+180m+448)M_4^2]ch}{(n-2)\Gamma^2} \\ &\quad - \frac{n^2[(4m^3+46m^2+328m+580)M_4+2m^3+32m^2+228m+272]ch}{(n-2)\Gamma^2} \\ &\quad < 0 \Leftarrow b \ge \underline{b}, M_4 \ge 0, \quad \text{(A.31a)}\end{aligned}$$

$$\frac{\partial \check{y}_f}{\partial m} = \frac{n^3[2mN_2^2+(6m-1)N_2+m^2+3m-2]ch}{\Gamma^2} > 0, \tag{A.31b}$$

$$\begin{aligned}\frac{\partial(\check{y}_e-\check{y}_f)}{\partial m} &= -\frac{n^2[n^2(n-m-1)^2b+[N_2^4+(2m+7)N_2^3+(2m^2+9m+18)N_2^2]c]h}{\Gamma^2} \\ &\quad - \frac{n^2[(5m^2+12m+20)N_2+(m+2)(m^2+4)]ch}{\Gamma^2} < 0, \quad \text{(A.31c)}\end{aligned}$$

$$\begin{aligned}\frac{\partial \check{x}_i}{\partial m} &= -\frac{2mn^3(n-2)(n-m-1)^2(b-\underline{b})h}{(n-2)\Gamma^2} - \frac{n[2mM_4^5+(6m^2+24m+1)M_4^4]ch}{(n-2)\Gamma^2} \\ &\quad - \frac{n[(6m^3+57m^2+102m+14)M_4^3]ch}{(n-2)\Gamma^2} \\ &\quad - \frac{n[(2m^4+41m^3+183m^2+166m+72)M_4^2]ch}{(n-2)\Gamma^2} \\ &\quad - \frac{n[(8m^4+84m^3+216m^2+24m+160)M_4]ch}{(n-2)\Gamma^2}\end{aligned}$$

$$- \frac{n[4m^4 + 48m^3 + 56m^2 - 128m + 128]ch}{(n-2)\Gamma^2} < 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0, \tag{A.31d}$$

$$\frac{\partial(\check{y}_e - \check{x}_e)}{\partial m} = -\frac{n^3(n-2m)(n-m-1)^2bh + n[N_2^5 + (m+9)N_2^4 + (6m+32)N_2^3]ch}{\Gamma^2}$$
$$- \frac{n[4(3m+14)N_2^2 + (2m^3 - m^2 + 8m + 48)N_2 + 3m^3 - 2m^2 + 16]ch}{\Gamma^2}$$
$$< 0 \Leftarrow m \leq n/2, \tag{A.31e}$$

$$\frac{\partial(\check{y}_f - \check{x}_f)}{\partial m} = \frac{2mn^3(n-m-1)^2bh + mn[2N_2^4 + 2(2m+7)N_2^3 + 2(m^2+9m+18)N_2^2]ch}{\Gamma^2}$$
$$+ \frac{mn[(4m^2 + 25m + 40)N_2 + m^3 + m^2 + 10m + 16]ch}{\Gamma^2} > 0, \tag{A.31f}$$

$$\frac{\partial m(\check{y}_e - \check{x}_e)}{\partial m} = -\frac{mn^3(2n-3m)(n-m-1)^2bh + nm[2N_2M_4^5 + (8m-2)N_2M_4^4]ch}{\Gamma^2}$$
$$- \frac{nm^2[2(11m-9)N_2M_4^3 + (14m^2 - 23m + 2)N_2M_4^2]ch}{2\Gamma^2}$$
$$- \frac{nm^3[(17m^2 - 30m + 8)N_2M_4 + 2m(m^2-3)]ch}{8\Gamma^2} < 0 \Leftarrow m \leq 2n/3, \tag{A.31g}$$

where $N_i := n - i$. This proves the remainder of the proposition. □

Proof of Proposition 3. The welfare of each country is given by $W_i = ay_i - \frac{b}{2}y_i^2 - \frac{c}{2}x_i^2 - p(y_i - x_i) - hx$. Substituting $p = a - by_i$ from (4) and ... yields

$$W_i^* = \frac{(a-nh)^2}{2(b+c)}, \tag{A.32}$$

$$W_i^\circ = \frac{\{[(n-1)b + nc]a - nch\}\{[(n-1)b + nc]a - nch - 2n(n-1)(b+c)h\}}{2[(n-1)b + nc]^2(b+c)}. \tag{A.33}$$

Substituting $p = a - by_f$ from (4) and (A.30) yields

$$\check{W}_e - W_i^\circ > 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0, \tag{A.34a}$$

$$\check{W}_f - W_i^\circ > 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0, \tag{A.34b}$$

$$\check{W}_f - \check{W}_e = \frac{bm^2n^4h^2(n-m-1)^2}{2\Gamma^2} > 0, \tag{A.34c}$$

$$\check{W} - W^\circ > 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0. \tag{A.34d}$$

Differentiating with respect to m yields

$$\frac{\partial(\check{W}_e - W_i^\circ)}{\partial m} > 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0, \tag{A.35a}$$

$$\frac{\partial(\check{W}_f - W_i^\circ)}{\partial m} > 0 \Leftarrow b \geq \underline{b}, M_4 \geq 0, \tag{A.35b}$$

$$\frac{\partial(\check{W}_f - \check{W}_e)}{\partial m} = \frac{n^2(n-m-1)^2b + [M_2^4 + (2m+7)M_2^3 + (2m^2+9m+18)M_2^2]c}{\Gamma^3/[mn^4(n-m-1)bh^2]}$$
$$+ \frac{[(5m^2 + 12m + 20)M_2 + (m+2)(m^2+4)]c}{\Gamma^3/[mn^4(n-m-1)bh^2]} > 0, \tag{A.35c}$$

$$\frac{\partial(\check{W}-W^{\circ})}{\partial m} > 0 \Leftarrow b \geq \underline{b}, M_5 \geq 0. \tag{A.35d}$$

□

Proof of Proposition 4. Substituting $\check{W}_e$ and $\check{W}_f$ into $\Phi(m) \coloneqq W_e(m) - W_f(m-1)$ yields

$$\begin{aligned}\Phi(m) = &-\frac{n^2(n-m)c^3h^2}{2[\Gamma(m)\Gamma(m-1)]^2}\{n^6(n-m)(n-m-1)^2(m^2-4m+2)\left(\frac{b}{c}\right)^3\\
&+n^4(n-m)(n-m-1)[(2m^2-8m+4)n^3-(2m^3-8m^2+4)n^2\\
&-(2m^4-6m^3-2m^2+6m-1)n+2m^5-8m^4+6m^3-2m^2-m+1]\left(\frac{b}{c}\right)^2\\
&+n^2[(m^2-4m+2)n^7-(3m^3-12m^2+2m+6)n^6\\
&+(m^4-6m^3+6m^2-2m+5)n^5+(5m^5-16m^4-10m^3+16m^2-3m+2)n^4\\
&-(5m^6-20m^5+9m^4-6m^3+10m^2-2m+1)n^3\\
&-(m^7-17m^5+26m^4-12m^3+4m^2-5m+2)n^2\\
&+(m-1)(3m^7-7m^6-5m^5+3m^4+3m^3-9m^2+5m-1)n\\
&-m(m-1)^2(m^6-2m^5+m^4+m^2+2m-1)]\frac{b}{c}\\
&-(n-m)[n^2-(3m^2-4m+1)n-m^3+2m^2-m]\\
&\cdot[2n^5-2mn^4-(4m^2-2m+2)n^3+(4m^3-4m^2+2m-1)n^2\\
&+(2m^4-2m^3+m^2-2m+1)n-2m^5+4m^4-m^3-2m^2+m]\}.\end{aligned} \tag{A.36}$$

Differentiating with respect to m yields

$$\frac{\partial\Phi(m)}{\partial m} = -\frac{n^2c^5h^2\Omega}{[\Gamma(m)\Gamma(m-1)]^3}, \tag{A.37}$$

where $\Omega > 0$ and, thus, $\frac{\partial\Phi(m)}{\partial m} < 0$ for $b \geq \underline{\underline{b}}$ if $m \geq 4$ and $m \leq n-2$. Substituting $m = 2$, $m = 3$ and $m = 4$ into (A.36) yields

$$\begin{aligned}\Phi(2) = &-\frac{n^2(n-2)c^3h^2}{2[\Gamma(2)\Gamma(1)]^2}\{2n^6(n-2)(n-3)^2\left(\frac{b}{c}\right)^3+n^4(n-2)(n-3)(4N_6^3+60N_6^2\\
&+275N_6+379)\left(\frac{b}{c}\right)^2+n^2(2N_6^7+70N_6^6+1015N_6^5+7886N_6^4+35357N_6^3\\
&+91154N_6^2+124511N_6+69016)\left(\frac{b}{c}\right)+(n-2)(N_6^2+7N_6+4)(2N_6^5+228N_6^4\\
&+2305N_6^3+3223N_6^2+8237N_6+24058)\},\end{aligned} \tag{A.38a}$$

$$\Phi(3) = -\frac{n^2(n-3)c^3h^2}{2[\Gamma(3)\Gamma(2)]^2}\{2n^6(n-3)(n-4)^2\left(\frac{b-\underline{\underline{b}}}{c}\right)^3+n^4(n-3)(n-4)(5N_{13}^3$$

$$+ 139N_{13}^2 + 1222N_{13} + 3304)\left(\frac{b-\underline{\underline{b}}}{c}\right)^2 + n^2(8N_{13}^7 + 524N_{13}^6 + 14470N_{13}^5$$

$$+ 217582N_{13}^4 + 1913605N_{13}^3 + 9759220N_{13}^2 + 26330627N_{13} + 28169264)\left(\frac{b-\underline{\underline{b}}}{c}\right)$$

$$+ 4N_{13}^9 + 336N_{13}^8 + 12357N_{13}^7 + 260274N_{13}^6 + 3443033N_{13}^5 + 29436094N_{13}^4$$

$$+ 160541645N_{13}^3 + 525521048N_{13}^2 + 886054121N_{13} + 488441488\}$$

$$= -\frac{n^2(n-3)c^3h^2}{2(n-2)^3[\Gamma(3)\Gamma(2)]^2}\{2n^6(n-2)^3(n-3)(n-4)^2\left(\frac{b-\underline{b}}{c}\right)^3 + n^4(n-2)^2(n-3)$$

$$\cdot (n-4)(5N_{10}^4 + 152N_{10}^3 + 1671N_{10}^2 + 7794N_{10} + 12800)\left(\frac{b-\underline{b}}{c}\right)^2 + n^2(n-2)$$

$$\cdot (8N_{10}^9 + 544N_{10}^8 + 16214N_{10}^7 + 277496N_{10}^6 + 2997965N_{10}^5 + 21131059N_{10}^4$$

$$+ 96697048N_{10}^3 + 274941348N_{10}^2 + 435274496N_{10} + 285584384)\left(\frac{b-\underline{b}}{c}\right) + 4N_{10}^{12}$$

$$+ 372N_{10}^{11} + 15681N_{10}^{10} + 395497N_{10}^9 + 6632298N_{10}^8 + 77669250N_{10}^7$$

$$+ 648515864N_{10}^6 + 3865190452N_{10}^5 + 16152917640N_{10}^4 + 45327176224N_{10}^3$$

$$+ 78090355680N_{10}^2 + 67110609664N_{10} + 12951611392\}, \quad \text{(A.38b)}$$

$$\Phi(4) = -\frac{n^2(n-4)c^3h^2}{2[\Gamma(4)\Gamma(3)]^2}\{2n^6(n-4)(n-5)^2\left(\frac{b-\underline{\underline{b}}}{c}\right)^3 + n^4(n-4)(n-5)(10N_6^3 + 86N_6^2$$

$$+ 181N_6 + 259)\left(\frac{b-\underline{\underline{b}}}{c}\right)^2 + n^2(16N_6^7 + 294N_6^6 + 2077N_6^5 + 8136N_6^4 + 22965N_6^3$$

$$+ 43224N_6^2 + 42013N_6 + 14570)\left(\frac{b-\underline{\underline{b}}}{c}\right) + 8N_6^9 + 188N_6^8 + 1738N_6^7 + 9070N_6^6$$

$$+ 38485N_6^5 + 150572N_6^4 + 397866N_6^3 + 557554N_6^2 + 334304N_6 + 38440\}. \quad \text{(A.38c)}$$

m being internally stable implies $m-1$ being externally unstable. Thus, $m=1$ is externally unstable and $m=2$ is internally stable for $n \geq 6$, and $m=2$ is externally unstable and $m=3$ is internally stable for $n \geq 13$ or $b \geq \underline{b}$ and $n \geq 10$. Furthermore, $m=4$ is internally unstable for $n \geq 6$. Substituting $m = n-1$ into (A.36) yields

$$\Phi(n-1) = -\frac{[n^2(n^2-8n+8)b - 16(n-1)^2c]h^2}{2n^2(b-\underline{\underline{b}})}$$

$$= -\frac{[n^2(n^2-8n+8)(b-\underline{\underline{b}}) + (N_{13}^4 + 34N_{13}^3 + 392N_{13}^2 + 1630N_{13} + 1127)c]h^2}{2n^2(b-\underline{\underline{b}})}$$

$$= -\frac{n^2(n-2)(n^2-8n+8)(b-\underline{b})h^2}{2n^2(n-2)(b-\underline{\underline{b}})}$$

$$- \frac{(N_{10}^5 + 36N_{10}^4 + 484N_{10}^3 + 2904N_{10}^2 + 6832N_{10} + 1952)ch^2}{2n^2(n-2)(b-\underline{\underline{b}})}. \quad \text{(A.39)}$$

Thus, $m = n-1$ is internally stable for $n = 6$, and it is internally unstable for $n \geq 13$ or $b \geq \underline{b}$ and $n \geq 10$. $\square$

A.2 Proofs of Section 4

$$y_i^\circ = x_i^\circ = \frac{(1+\mu)a[(n-1)b+nc]-nch}{[(n-1)b^2+2nbc+nc^2]\mu+[(n-1)b+nc](b+c)} > 0 \Leftarrow a \geq nh, \tag{A.40a}$$

$$y_i^* = x_i^* = \frac{(1+\mu)a-nh}{(2b+c)\mu+b+c} > 0 \Leftarrow a \geq nh, \tag{A.40b}$$

$$y_i^\circ - y_i^* = \frac{(1+\mu)(n-1)(b+c)[\mu a+(b+c)hn]}{[(2b+c)\mu+b+c]\{[(n-1)b^2+2nbc+nc^2]\mu+[(n-1)b+nc](b+c)\}} > 0. \tag{A.40c}$$

Differentiating with respect to μ yields

$$\frac{\partial y_i^\circ}{\partial \mu} = \frac{\partial x_i^\circ}{\partial \mu} = -\frac{c\{ab[(n-1)b+nc]-[n(b+c)^2-b^2]nh\}}{\{[(n-1)b^2+2nbc+nc^2]\mu+[(n-1)b+nc](b+c)\}^2}, \tag{A.41a}$$

$$\frac{\partial y_i^*}{\partial \mu} = \frac{\partial x_i^*}{\partial \mu} = -\frac{ab-(2b+c)nh}{[(2b+c)\mu+b+c]^2}, \tag{A.41b}$$

$$\frac{\partial(y_i^\circ - y_i^*)}{\partial \mu} = \ldots \tag{A.41c}$$

Using (A.18), (A.19) and (A.20), solving (A.21) and (A.22) for χ_f and χ_e for $\mu > 0$ yields

$$\chi_f = \frac{n\{\mu[(na-m^2h)b+mac]+(n^2-m^2-nm)(b+c)h\}c}{\Psi}, \tag{A.42}$$

$$\chi_e = \frac{-\mu^2 nm(n-m)abc+n[nm(n-m-1)b+(n^2-m^2-mn)c](b+c)h}{\Psi} - \frac{\mu n\{[(mn-m^2-n)b-cm]ac-m[(n-m-1)nb+(n^2-nm-m)c]bh\}}{\Psi}, \tag{A.43}$$

and

$$\chi_e - \chi_f = \frac{nm\{(1+\mu)(n-m-1)[(b+c)nh-\mu ac]-\mu[(1+\mu)a-nh]c\}b}{\Psi}. \tag{A.44}$$

where

$$\Psi := -\mu^2 m^2(n-m)bc+\mu[(m^3-nm^2+n^2)b+nmc]c+(1+\mu)(b+c)\Gamma. \tag{A.45}$$

Note that $a \geq nh$ implies $[(\chi_e-\chi_f)\Psi]|_{m=n-1} < 0$.

Substituting (A.42) and (A.43) into (A.18), (A.19) and (A.20) yields

$$\hat{y}_e = \frac{(1+\mu)n^2(n-m-1)(a-mh)b+n^2(n-m)(n-m-1)hc}{\Psi} + \frac{[(n+m)(n-m)^2-nm+m(n-m)^2\mu][(1+\mu)a-nh]c}{\Psi}, \tag{A.46a}$$

$$\hat{y}_f = \frac{(1+\mu)n^2(n-m-1)ab + n^3(n-m-1)hc}{\Psi} + \frac{[(n+m)(n-m)^2 - nm - m^2(n-m)\mu][(1+\mu)a - nh]c}{\Psi}, \tag{A.46b}$$

$$\hat{x}_i = \frac{(1+\mu)n(n-m-1)(na - m^2h)b + n(n+m)(n-m)(n-m-1)hc}{\Psi} + \frac{[(n+m)(n-m)^2 - nm][(1+\mu)a - nh]c}{\Psi}. \tag{A.46c}$$

For $m = n-1$, we have

$$\hat{y}_e|_{m=n-1} = -\frac{(n-1)\left[\frac{n^2-3n+1}{n-1} - \mu\right][(1+\mu)a - nh]c}{\Psi}, \tag{A.47a}$$

$$\hat{y}_f|_{m=n-1} = -\frac{(n-1)^2\left[\frac{n^2-3n+1}{(n-1)^2} + \mu\right][(1+\mu)a - nh]c}{\Psi}, \tag{A.47b}$$

$$\hat{x}_i|_{m=n-1} = -\frac{[n^2-3n+1][(1+\mu)a - nh]c}{\Psi}, \tag{A.47c}$$

$$\begin{aligned}
\Psi|_{m=n-1} &= -[n^2 - 3n + 1 + (n^2 - 5n + 2)\mu + (n^2 - 2n + 1)\mu^2]bc \\
&\quad - [n^2 - 3n + 1 - (2n-1)\mu]c^2 \\
&= -[n^2 - 3n + 1 + (n^2 - 5n + 2)\mu + (n^2 - 2n + 1)\mu^2]bc(b - \underline{\underline{b}})c \\
&\quad - [(n-1)(n-4)(2n^2 - 6n + 2) + (n^4 - 17n^3 + 61n^2 - 60n + 16)\mu \\
&\quad + (n-1)^2(n^2 - 10n + 8)\mu^2]c^2/n^2.
\end{aligned} \tag{A.47d}$$

Thus, $(\hat{y}_e\Psi)|_{m=n-1} > 0$ and $\Psi|_{m=n-1} < 0$ must hold to ensure $\hat{y}_i|_{m=n-1}, \hat{x}_i|_{m=n-1} > 0$. $\mu < \overline{\mu} := \frac{n^2-3n+1}{n-1}$ is necessary for the former, and $n \geq 13$ or $n \geq 5$ and $\mu \leq \frac{11}{9}$ are sufficient for the latter. Furthermore, we have

$$\begin{aligned}
(\hat{y}_e\Psi) &= (1+\mu)n(n-m-1)\{(n-m)a(b - \underline{\underline{b}}) + m(a - nh)b\} \\
&\quad + 2(n-1)(n-4)(n-m)(n-m-1)hc + \mu m(n-m)^2[(1+\mu)a - nh]c \\
&\quad + [(54X^3 + 108X^2 + 54X + 8)N_5^4 + (783X^3 + 1629X^2 + 789X + 103)N_5^3 \\
&\quad + (4131X^3 + 9225X^2 + 4353X + 459)N_5^2 + (9369X^3 + 23571X^2 + 10995X \\
&\quad + 793)N_5 + 7695X^3 + 23355X^2 + 11025X + 365][(1+\mu)a - nh]cm^3/(8n^4) \\
&\quad > 0 \Leftarrow m \leq 2/3n,
\end{aligned} \tag{A.48a}$$

$$\begin{aligned}
\frac{\partial(\hat{y}_e\Psi)}{\partial m} &= -n^2(1+\mu)[a + (n-2m-1)h]b - \{[(n-m)[\mu(3m-n) + n + 3m + 1] + m] \\
&\quad \cdot [(1+\mu)a - nh] + n^2(2n - 2m - 1)h\}c < 0 \Leftarrow m \geq 1/3n,
\end{aligned} \tag{A.48b}$$

$$\begin{aligned}
\frac{\partial(\hat{y}_f\Psi)}{\partial m} &= -(1+\mu)n^2a(b - \underline{\underline{b}}) - \{[2M_2^2 + (6m-1)M_2 + m^2 + 3m - 2 + (2n-3m)\mu] \\
&\quad \cdot [(1+\mu)a - hn] + 2n(n-1)(n-4)h\}c < 0 \Leftarrow m \leq 2/3n,
\end{aligned} \tag{A.48c}$$

$$\frac{\partial(\hat{x}_i\Psi)}{\partial m} = -(1+\mu)\{n^2[a-(3m-2n+2)m/nh](b-\underline{\underline{b}}) + [2M_2^2+(6m-1)M_2+m^2+3m$$
$$-2](a-nh)c\} - \{[2M_2^4+(12m+7)M_2^3+(18m^2+23m+2)M_2^2+(8m^3+31m^2$$
$$-12)M_2+15m^3+10m^2-12m-8]\mu+2(n-1)(n-4)[M_2^2+4(m+1)M_2$$
$$+6m+4]\}hc < 0, \tag{A.48d}$$

$$\frac{\partial\Psi}{\partial m} = -(1+\mu)n^2b^2 - (1+\mu)[\mu m(2n-3m)+2(n-m)^2+(n-m)(6m+1)$$
$$+m(m+1)]bc - [(1+\mu)(n-m)(n+3m)+n]c^2 < 0 \Leftarrow m \leq 2/3n$$
$$= -(1+\mu)n^2b^2 - (1+\mu)[2M_2^2+(2\mu m+6m+9)M_2+m(m-4)(\tilde{\mu}-\mu)]bc$$
$$-[(1+\mu)(n-m)(n+3m)+n]c^2 < 0 \Leftarrow \mu \leq \tilde{\mu}. \tag{A.48e}$$

where $X := \frac{2n-3n}{3m}$ and $\tilde{u} := \frac{m^2+13m+10}{m(m-4)} \geq 1$. $(\hat{y}_e\Psi)$ being positive for $m \leq 2/3n$ implies that $(\hat{y}_f\Psi)$, $(\hat{x}_i\Psi)$ and Ψ must also be positive for $m \leq 2/3n$ to ensure $\hat{y}_i, \hat{x}_i > 0$ for $m \leq 2/3n$. $\frac{\partial(\hat{y}_f\Psi)}{\partial m}, \frac{\partial(\hat{x}_i\Psi)}{\partial m}, \frac{\partial\Psi}{\partial m}$ being negative for $m \leq 2/3n$ implies that $\hat{y}_i, \hat{x}_i > 0$ for $m \leq 2/3n$ is fulfilled if and only if $(\hat{y}_f\Psi)|_{m=2/3n}, (\hat{x}_i\Psi)|_{m=2/3n}, \Psi|_{m=2/3n} > 0$. Finally, $\frac{\partial(\hat{y}_e\Psi)}{\partial m}, \frac{\partial(\hat{x}_i\Psi)}{\partial m}, \frac{\partial\Psi}{\partial m}$ being negative for $m \leq n-2$ implies that $(\hat{y}_e\Psi), (\hat{x}_i\Psi), \Psi > 0$ for all $m \leq n-2$ if and only if $(\hat{y}_e\Psi)|_{m=n-2}, (\hat{x}_i\Psi)|_{m=n-2}, \Psi|_{m=n-2} > 0$.

In what follows, we search for parameter values such that $[(\chi_e-\chi_f)\Psi], (\hat{y}_e\Psi), \Psi \geq 0$ for $m \leq n-2$, which ensures that all quantities are positive for $m \leq n-2$. From (A.44), $[(\chi_e-\chi_f)\Psi]|_{m=n-2} \geq 0$ implies $[(\chi_e-\chi_f)\Psi] \geq 0$ for $m \leq n-2$. Rewriting (A.45) yields

$$\Psi = (b+c)\Gamma + \mu\{n^2(n-m-1)(b-\underline{\underline{b}})^2 + [4N_2^3+(8m+2)N_2^2$$
$$+m^2[(2m^2+7m-4)/m^2-\mu]M_4 + 2m^2[(m+2)/(2m)-\mu]](b-\underline{\underline{b}})c$$
$$+[4N_2^5+(16m-1)N_2^4+m^2[(21m^2+3m-16)/m^2-\mu]N_2^3$$
$$+2m^2(m-2)[(10m^3+17m^2-32m-28)/(2m^2(m-2))-\mu]N_2^2$$
$$+(m^2-2m-20)m^2[(m^4+13m^3+12m^2-52m-48)/((m^2-2m-20)m^2)-\mu]N_2$$
$$+2m^2(m^2-6m-8)[16(m+1)^2(m-2)/(2m^2(m^2-6m-8))-\mu]]c^2/n^2\}$$
$$> 0 \Leftarrow \mu \leq \min[(m+2)/(2m), 16(m+1)^2(m-2)/(2m^2(m^2-6m-8))]. \tag{A.49}$$

A.3 Proofs of Section 5

For $\phi = 0$, the joint welfare of a fringe country and its lobby group is given by

$$W_i = B_i[D_i(p)] - C_i[S_i(p-\chi_i)] - H_i\Big[\sum_{j\in N} S_j(p-\chi_j)\Big] + p[S_i(p-\chi_i) - D_i(p)]$$
$$+\mu_i\{pS_i(p-\chi_i) - C_i[S_i(p-\chi_i)]\}. \tag{A.50}$$

The first-order condition with respect to χ_i reads

$$0 = -[p - C_i' - H_i']S_i' + \Big\{[B_i' - p]D_i' + [p - C_i']S_i' - H_i' \sum_{j \in N} S_j' + x_i - y_i\Big\} \tfrac{\partial p}{\partial \chi_i}$$
$$+ \mu\Big\{-[p - C_i']S_i' + [[p - C_i']S_i' + x_i] \tfrac{\partial p}{\partial \chi_i}\Big\}. \quad \text{(A.51)}$$

Substituting (4) for $i \in F$ and rearranging yields

$$0 = -[(1+\mu_i)\chi_i - H_i']S_i' + \Big[(1+\mu_i)\chi_i S_i' - H_i' \sum_{j \in N} S_j' + (1+\mu_i)x_i - y_i\Big] \tfrac{\partial p}{\partial \chi_i}$$
$$\Leftrightarrow\ \chi_i = \frac{1}{1+\mu_i}\Big\{H_i' - \frac{\frac{\partial p}{\partial \chi_i}}{1 - \frac{\partial p}{\partial \chi_i}} \frac{1}{S_i'}\Big[H_i' \sum_{j \in N \setminus i} S_j' + y_i - (1+\mu_i)x_i\Big]\Big\}. \quad \text{(A.52)}$$

Indicating the fully uncooperative equilibrium by a circle, we get for $E = \emptyset$ and $F = N$

$$\chi_i^\circ = \frac{1}{1+\mu_i}\Big\{H_i' - \frac{\frac{\partial p}{\partial \chi_i}}{1 - \frac{\partial p}{\partial \chi_i}} \frac{1}{S_i'}\Big[H_i' \sum_{j \in N \setminus i} S_j' + y_i^\circ - (1+\mu_i)x_i^\circ\Big]\Big\}. \quad \text{(A.53)}$$

For $\phi = 0$, the joint welfare of the coalition countries and their lobby groups is given by

$$\sum_{j \in E} W_j = \sum_{j \in E} B_j[D_i(p)] - \sum_{j \in E} C_j[S_j(p - \chi_e)] \sum_{j \in E} H_j\Big[\sum_{j \in N} S_j(p - \chi_e)\Big]$$
$$+ p \sum_{j \in E}[S_j(p - \chi_e) - D_j(p)] + \sum_{j \in E} \mu_j\{pS_j(p - \chi_e) - C_j[S_j(p - \chi_e)]\}. \quad \text{(A.54)}$$

The first-order condition with respect to χ_e reads

$$0 = -\sum_{j \in E}\Big[p - C_j' - \sum_{j \in E} H_j'\Big]S_j' + \sum_{j \in E}\Big\{[B_j' - p]D_j' + [p - C_j']S_j' - H_j' \sum_{j \in N} S_j' + x_j - y_j\Big\} \tfrac{\partial p}{\partial \chi_e}$$
$$+ \Big\{-\sum_{j \in E} \mu_j[p - C_j']S_j' + \sum_{j \in E} \mu_j[[p - C_j']S_j' + x_j] \tfrac{\partial p}{\partial \chi_e}\Big\}. \quad \text{(A.55)}$$

Substituting (4) for $i \in E$ and rearranging yields

$$0 = -\sum_{j \in E}\Big[(1+\mu_j)\chi_e - \sum_{j \in E} H_j'\Big]S_j' + \sum_{j \in E}\Big[(1+\mu_j)\chi_e S_j' - H_j' \sum_{j \in N} S_j' + (1+\mu_j)x_j - y_j\Big] \tfrac{\partial p}{\partial \chi_e}$$
$$\Leftrightarrow\ \chi_e = \frac{\sum_{j \in E} S_j'}{\sum_{j \in E}(1+\mu_j)S_j'}\Big\{\sum_{j \in E} H_j' - \frac{\frac{\partial p}{\partial \chi_e}}{1 - \frac{\partial p}{\partial \chi_e}} \frac{\sum_{j \in E}}{\sum_{j \in E} S_j'}\Big[H_j' \sum_{j \in F} S_j' + y_j - (1+\mu_j)x_j\Big]\Big\}, \quad \text{(A.56)}$$

Indicating the fully cooperative equilibrium by an asterisk, we get for $E = N$ and $F = \emptyset$

$$\chi_e^* = \frac{S'}{\sum_{j \in N}(1+\mu_j)S_j'}\Big(\sum_{j \in N} H_j' + \frac{\frac{\partial p}{\partial \chi_e}}{1 - \frac{\partial p}{\partial \chi_e}} \frac{\sum_{j \in N}}{\sum_{j \in N} S_j'} \mu_j x_j\Big) > 0. \quad \text{(A.57)}$$

Proof of Lemma 2. Consider the symmetric specification (12) with $m = 1$. Then, substituting (7) into (A.52) and (A.56) yields

$$\chi_f = \frac{1}{1+\mu}\frac{(1+\mu)x_f - y_i - D'H_i'}{S_e' - S_f' + (n-1)S_f' - D'}, \tag{A.58}$$

$$\chi_e = \frac{1}{1+\mu}\frac{(1+\mu)x_e - y_i - D'H_i'}{(n-1)S_f' - D'}. \tag{A.59}$$

Totally differentiating $S_i'(p-\chi_i) = \frac{1}{C_i''(x_i)}$ and rearranging yields $S_i'' = -\frac{C_i'''}{(C_i'')^2} \cdot \frac{\mathrm{d}x_i}{\mathrm{d}(p-\chi_i)} = -\frac{C_i'''}{(C_i'')^3}$, such that $C_i''' \leq 0$ implies $S_i'' \geq 0$. Suppose $x_e > [<] x_f$, such that $S_e' > [<] S_f'$ holds. Then, (A.58) and (A.59) imply $\chi_e > [<] \chi_f$, which contradicts $x_e > [<] x_f$. Thus, $x_e = x_f = x_i$, such that

$$\chi_f = \chi_e = \chi_i = \frac{1}{1+\mu}\frac{\mu x_i - D'H_i'}{(n-1)S_i' - D'} > 0, \tag{A.60}$$

which coincides with χ_i° from (A.61b). □

Proof of Proposition 6. Consider the symmetric specification (12). Then, (A.52), (A.53), (A.56) and (A.57) become

$$\chi_f = \frac{1}{1+\mu}\Big[-\frac{D'H_i'}{mS_e' + (n-m-1)S_f' - D'} + \frac{x_f - y_f}{mS_e' + (n-m-1)S_f' - D'}\Big] + \frac{\mu}{1+\mu}\frac{x_f}{mS_e' + (n-m-1)S_f' - D'}, \tag{A.61a}$$

$$\chi_i^\circ = -\frac{1}{1+\mu}\frac{D'H_i'}{(n-1)S_i' - D'} + \frac{\mu}{1+\mu}\frac{x_i^\circ}{(n-1)S_i' - D'} > 0, \tag{A.61b}$$

$$\chi_e = \frac{m}{1+\mu}\Big[-\frac{D'H_i'}{(n-m)S_f' - D'} - \frac{y_e - x_e}{(n-m)S_f' - D'}\Big] + \frac{\mu m}{1+\mu}\frac{x_e}{(n-m)S_f' - D'}, \tag{A.61c}$$

$$\chi_i^* = \frac{n}{1+\mu}H_i' - \frac{\mu n}{1+\mu}\frac{x_i^*}{D'} > 0. \tag{A.61d}$$

Using $m(y_e - x_e) = (n-m)(x_f - y_f)$, we get

$$\begin{aligned}\chi_e - \chi_f = &-\frac{1}{1+\mu}\frac{\{m^2(S_e' - S_f') + (m-1)[nS_f' - D']\}D'H_i'}{[(n-m)S_f' - D'][mS_e' + (n-m-1)S_f' - D']} \\ &+ \frac{1}{1+\mu}\frac{\{(n-m)S' - (n-m+1)D'\}(y_f - x_f)}{[(n-m)S_f' - D'][mS_e' + (n-m-1)S_f' - D']} \\ &+ \frac{\mu}{1+\mu}\frac{[m^2(S_e' - S_f') + (m-1)[nS_f' - D']]x_e + [(n-m)S_f' - D'](x_e - x_f)}{[(n-m)S_f' - D'][mS_e' + (n-m-1)S_f' - D']}.\end{aligned} \tag{A.62}$$

Totally differentiating $S_i'(p-\chi_i) = \frac{1}{C_i''(x_i)}$ and rearranging yields $S_i'' = -\frac{C_i'''}{(C_i'')^2} \cdot \frac{\mathrm{d}x_i}{\mathrm{d}(p-\chi_i)} = -\frac{C_i'''}{(C_i'')^3}$, such that $C_i''' \leq 0$ implies $S_i'' \geq 0$. Suppose $\chi_e \leq \chi_f$, such that $x_e \geq x_f$ and $S_e' \geq S_f'$

as well as $y_f - x_f \geq 0$ hold. Then, the first line and the third line of (A.62) are positive, and the second line of (A.62) is non-negative, which contradicts $\chi_e \leq \chi_f$. $\chi_e > \chi_f$ implies $x_e < x_f$ and $y_f - x_f < 0$, such that χ_f from (A.61a) is positive. From (8), we get

$$\tilde{W}_i = \int_0^{\tilde{y}_i} \left[B_i'(y_i) - p\right] \mathrm{d}y_i + \int_0^{\tilde{x}_i} \left[p - C_i'(x_i)\right] \mathrm{d}x_i - H_i(\tilde{x}), \tag{A.63}$$

$$\tilde{W}_f - \tilde{W}_e = \int_{\tilde{x}_e}^{\tilde{x}_f} \left[p - C_i'(x_i)\right] \mathrm{d}x_i. \tag{A.64}$$

Since production is not subsidized, i.e. $p - C_i'(x_i) = \chi_i > 0$ for all $x_i \in [0, \hat{x}_i]$, a fringe country's producer surplus and, thus, welfare exceeds that of a coalition country. This proves the first bullet of the proposition.

Totally differentiating $D_i'(p) = \frac{1}{B_i''(y_i)}$ and rearranging yields $D_i'' = -\frac{B_i'''}{(B_i'')^2} \cdot \frac{\mathrm{d}y_i}{\mathrm{d}p} = -\frac{B_i'''}{(B_i'')^3}$, such that $B_i''' \geq 0$ implies $D_i'' \geq 0$. Suppose $\chi_e > \chi_f \geq \chi_i^*$ and $y_e = y_f \geq y_i^*$. Then, $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ implies $x_e < x_f \leq x_i^*$, which contradicts $y_e = y_f \geq y_i^*$. Now suppose $\chi_e > \chi_f \geq \chi_i^*$ and $y_e = y_f < y_i^*$, such that $H_i'(mx_e + (n-m)x_f) \leq H_i'(nx_i^*)$ and $x_e < x_i^*$. For $D_i'' \geq 0$ or $\mu = 0$, comparing (A.61c) and (A.61d) then implies $\chi_e < \chi_i^*$, which contradicts $\chi_e > \chi_f \geq \chi_i^*$. Thus, $\chi_f < \chi_i^*$ for $D_i'' \geq 0$ or $\mu = 0$. Now suppose $\chi_e \geq \chi_i^* > \chi_f$. For $D_i'' \geq 0$ or $\mu = 0$ and $H_i'' \geq 0$, comparing (A.61c) and (A.61d) then implies $y_e = y_f > y_i^*$. Then, $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ implies $x_e < x_i^* < x_f$. For $D_i'' = 0$ or $\mu = 0$ and $H_i'' = 0$, $x_e < x_i^*$ implies $\chi_e < \chi_i^*$. Finally, suppose $\chi_i^* > \chi_e > \chi_f$ and $y_e = y_f \leq y_i^*$. Then, $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ implies $x_f > x_e > x_i^*$, which contradicts $y_e = y_f \leq y_i^*$. Thus, $y_e = y_f > y_i^*$ for $D_i'' \geq 0$ or $\mu = 0$, which implies $x_f > x_i^*$. This proves the second bullet of the proposition.

Suppose $y_e = y_f \geq y_i^\circ$. For $D_i'' = S_i'' = 0$, comparing (A.61a) and (A.61b) then implies $\chi_e > \chi_f > \chi_i^\circ$. Then, $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ implies $x_e < x_f < x_i^\circ$, which contradicts $y_e = y_f \geq y_i^\circ$. $y_e = y_f < y_i^\circ$ and $x_e < x_f$ then implies $x_e < x_i^\circ$, and $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ then implies $\chi_e > \chi_i^\circ$. Now suppose $\chi_f \leq \chi_i^\circ$. For $D_i'' = S_i'' = 0$ and $H_i' = 0$, comparing (A.61a) and (A.61b) then implies $x_f < x_i^\circ$. Then, $B_i'(y_i) = C_i'(x_i) + \chi_i$ with $B_i'' < 0$ and $C_i'' > 0$ implies $y_e = y_f > y_i^\circ$, which contradicts $y_e = y_f \geq y_i^\circ$. Thus, $\chi_f > \chi_i^\circ$ for $D_i'' = S_i'' = 0$ and $H_i' = 0$. This proves the last bullet of the proposition. □

Substituting (13) into (A.61a) and (A.61c) yields

$$\chi_f = \frac{1}{1+\mu}\Big[\frac{nch}{(n-1)b + nc} - \frac{bc(y_f - x_f)}{(n-1)b + nc}\Big] + \frac{\mu}{1+\mu}\frac{bcx_f}{(n-1)b + nc}, \tag{A.65}$$

$$\chi_e = \frac{m}{1+\mu}\Big[\frac{nch}{(n-m)b+nc} - \frac{bc(y_e-x_e)}{(n-m)b+nc}\Big] + \frac{\mu m}{1+\mu}\frac{bcx_e}{(n-m)b+nc}. \tag{A.66}$$

Using (A.18), (A.19) and (A.20), solving (A.65) and (A.66) for χ_f and χ_e yields

$$\chi_f = \frac{nc[ab\mu + nh(b+c)]}{\Lambda}, \tag{A.67}$$

$$\chi_e = \frac{nmc[ab\mu + nh(b+c)]}{\Lambda}, \tag{A.68}$$

and

$$\chi_e - \chi_f = \frac{n(m-1)c[ab\mu + nh(b+c)]}{\Lambda}, \tag{A.69}$$

where

$$\Lambda \coloneqq [(n-m)(n+m-1)b^2 + 2n^2bc + n^2c^2]\mu + [(n-m)(n+m-1)b + n^2c](b+c) > 0. \tag{A.70}$$

Proof of Proposition 7. Substituting (A.67) and (A.68) into (A.18), (A.19) and (A.20), and differentiating with respect to m yields

$$\tfrac{\partial \chi_e}{\partial m} = \frac{nc\{[(m^2+n^2-n)b^2 + 2bcn^2 + c^2n^2]\mu + [(m^2+n^2-n)b + cn^2](b+c)\}}{\Lambda^2/[ab\mu + nh(b+c)]} > 0, \tag{A.71a}$$

$$\tfrac{\partial \chi_f}{\partial m} = \frac{n(2m-1)[b\mu + b + c]bc}{\Lambda^2/[ab\mu + nh(b+c)]} > 0, \tag{A.71b}$$

$$\tfrac{\partial (\chi_e - \chi_f)}{\partial m} = \frac{nc\{[[n(n-1) + (m-1)^2]b^2 + 2n^2bc + n^2c^2]\mu + [[n(n-1) + (m-1)^2]b + n^2c](b+c)\}}{\Lambda^2/[ab\mu + nh(b+c)]} > 0, \tag{A.71c}$$

$$\tfrac{\partial y_i}{\partial m} = -\frac{(1+\mu)n^2(2m-1)c(b+c)}{\Lambda^2/[ab\mu + nh(b+c)]} < 0, \tag{A.71d}$$

$$\tfrac{\partial x_e}{\partial m} = -\frac{n\{[(n-m)^2b^2 + cn(2n-2m+1)b + c^2n^2]\mu + ((n-m)^2b + cn^2)(b+c)\}}{\Lambda^2/[ab\mu + nh(b+c)]} < 0, \tag{A.71e}$$

$$\tfrac{\partial x_f}{\partial m} = \frac{n(2m-1)b\{[(n-1)b + nc]\mu + (n-1)(b+c)\}}{\Lambda^2/[ab\mu + nh(b+c)]} > 0, \tag{A.71f}$$

$$\tfrac{\partial x}{\partial m} = n\tfrac{\partial y_i}{\partial m} < 0, \tag{A.71g}$$

$$\begin{aligned}\tfrac{\partial (y_e - x_e)}{\partial m} &= \frac{n[(n-m)^2b^2 + n(n+1-2m)c(2b+c)]\mu}{\Lambda^2/[ab\mu + nh(b+c)]} \\ &\quad + \frac{n[(n-m)^2b + n(n+1-2m)c](b+c)}{\Lambda^2/[ab\mu + nh(b+c)]} > 0 \Leftarrow m \le (n+1)/2,\end{aligned} \tag{A.71h}$$

$$\tfrac{\partial (y_f - x_f)}{\partial m} = -\frac{n(2m-1)\{[(n-1)b^2 + 2nbc + nc^2]\mu + [(n-1)b + nc](b+c)\}}{\Lambda^2/[ab\mu + nh(b+c)]} < 0, \tag{A.71i}$$

$$\begin{aligned}\tfrac{\partial m(y_e - x_e)}{\partial m} &= \frac{\{(n-m)^2[(2m-1)n + (m-1)^2]b^2 + n^2[(2m-1)(n+1-2m) + (m-1)^2](2b+c)c\}\mu}{\Lambda^2/[ab\mu + nh(b+c)]} \\ &\quad + \frac{\{(n-m)^2[(2m-1)n + (m-1)^2]b + n^2[(2m-1)(n+1-2m) + (m-1)^2]c\}(b+c)}{\Lambda^2/[ab\mu + nh(b+c)]} \\ &\quad > 0 \Leftarrow m \le (n+1)/2,\end{aligned} \tag{A.71j}$$

Since $x_e < y_e = y_f < x_f$ and $\frac{\partial x_e}{\partial m} < 0$, x_i^* being positive is for $m < n$ sufficient and for $m = n$ necessary for all quantities being positive. Substituting $m = n$ into x_e yields

$$x_i^* = \frac{a(1+\mu) - nh}{(2b+c)\mu + b + c}, \tag{A.72}$$

which is positive for all $\mu \geq 0$ if and only if $a > nh$. □

Proof of Proposition 8. The joint welfare of each country and its lobby group is given by $W_i = ay_i - \frac{b}{2}y_i^2 - \frac{c}{2}x_i^2 - p(y_i - x_i) - hx + \mu\left(px_i - \frac{c}{2}x_i^2\right)$. Substituting $p = a - by_i$ from (4) and ... yields

$$W_i^* = \frac{[(1+\mu)a - nh]^2}{2[(2b+c)\mu + b + c]}, \tag{A.73}$$

$$W_i^\circ = ... \tag{A.74}$$

Substituting $p = a - by_f$ from (4) and ... yields

$$\tilde{W}_e - W_i^\circ = ..., \tag{A.75a}$$

$$\tilde{W}_f - W_i^\circ = ..., \tag{A.75b}$$

$$\tilde{W}_f - \tilde{W}_e = \frac{(1+\mu)(m^2-1)n^2[\mu ba + n(b+c)h]^2 c}{2\Lambda^2} > 0, \tag{A.75c}$$

$$\tilde{W} - W^\circ = ... \tag{A.75d}$$

Differentiating with respect to m yields

$$\begin{aligned}\frac{\partial(\tilde{W}_e - W_i^\circ)}{\partial m} &= \{(1+\mu)n^2[\mu ba + n(b+c)h]^2\{(1+\mu)(n-m)[m^2+(m-1)n]b^2 \\ &\quad + [2\mu(m-1)n^2 + 2(m-1)(n-m)^2 + m(4m-3)(n-m) + m^2(m-1)]bc \\ &\quad + (1+\mu)(m-1)n^2c^2\}c\}/\Lambda^3 > 0, \end{aligned} \tag{A.76a}$$

$$\frac{\partial(\tilde{W}_f - W_i^\circ)}{\partial m} = ..., \tag{A.76b}$$

$$\begin{aligned}\frac{\partial(\tilde{W}_f - \tilde{W}_e)}{\partial m} &= \{(1+\mu)n^2[\mu ba + n(b+c)h]^2\{(1+\mu)[m^3 + (n^2-n-2)m + 1]b^2 \\ &\quad + [m^3 + [2(1+\mu)n^2 - n - 2]m + 1]bc + (1+\mu)mn^2c^2\}c\}/\Lambda^3 > 0, \end{aligned} \tag{A.76c}$$

$$\frac{\partial(\tilde{W} - W^\circ)}{\partial m} = ... \tag{A.76d}$$

□

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