

Constitutional Choice, Federal Grants, and International Environmental Agreements?¹

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Abstract

In this paper, we analyze how the prospect of international negotiations over transboundary pollution shape the countries' constitutional and political decisions that precede the bargaining process. We show that the countries' dominant strategy at the constitutional stage is to assign the authority over environmental policy and international negotiations to the governments of the polluting regions. Although this decentralization of power is usually accompanied by federal grant schemes, there is no 'fair' cost sharing within each country. The negotiating regions' shares of the national benefits falls short of the corresponding shares of costs. This depresses the bargaining incentives of the regional negotiators and leads to a suboptimal international environmental agreement from the perspective of the countries as a whole.

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1 Motivation

Most environmental problems are to some extent international or, more precisely, interregional by nature. Economic activities not only pollute the environment in the areas where they take place but also in other regions within the national boundaries and beyond. In other words, they cause externalities on the national level (between regions of the same country) and on the international level (between regions of different countries). Since non-cooperatively acting governments ignore the negative impact on the environment outside their jurisdictions, they usually end up in a prisoners' dilemma. The pollution levels are inefficiently high or, coming to the same, the abatement levels are inefficiently low.

Internalizing the international externalities is particularly difficult. In the absence of a coercive supranational power, the countries rely on international environmental agreements (IEAs). A federal country can approach the necessary negotiations in two fundamentally different ways: the power to decide on environmental policy and to negotiate abatement levels can be assigned either to the federal government or to the governments of the polluting regions. This issue is usually already settled at a constitutional stage at which the political structure and the distribution of power are codified. While in the centralized system the negotiating politicians are obliged to their country as a whole, in the decentralized system they only represent the interests of their regions. Since the two alternative negotiating agents substantially differ in their interests, the constitutionally design profoundly affects the country's position in the international bargaining process. A country can use this constitutional delegation of decisions to gain an advantage in international negotiations.¹ Moreover, if the decentralized system is adopted, the federal government can accompany this institutional arrangement by a grant scheme. This 'conventional' political instrument can serve as a means to fine tune the bargaining incentives of the polluting regions. Ultimately, rather long-term constitutional designs combined with relatively short-term political measures substantially shape the outcome of IEAs.

This gives rise to two questions: First, what constitution-and-policy mix is chosen by a non-cooperatively acting country? And second, how do the resulting strategies affect the outcome of an IEA? Both issues are analyzed in the current paper. To this end, we consider a simple world with two symmetric countries, each of them consisting of two regions. In each country, one of the two regions hosts 'dirty'

¹The constitutional design which assigns authority over environmental policies uses rather similar arguments as the economic theory of fiscal federalism. E.g. Oates (1972) famous 'decentralization theorem' attributes the governmental tasks to that federal or regional stage where internalizing the spillovers can be tackled best.

industries that generate transboundary pollution. Each country first decides at the constitutional stage whether the federal or the regional authorities are entitled to determine environmental policy and to negotiate an IEA. Afterward, each federal government can implement a grant scheme to cover abatement costs in its country's polluting region and to transfer payments to this region that are related to the national abatement benefits. Finally, the governments in charge of international negotiations enter Nash bargaining over binding abatement targets.

We show that, at the constitutional stage, the two countries delegate the authority to decide on environmental policy and to negotiate an IEA to the regional governments. This decentralization of power is usually accompanied by a federal grant scheme. If a federal government implements a combination of matching and benefit-related grants, then these transfers are such that the polluting region's share of the abatement costs exceeds its share of the country's abatement benefits. Since such a scheme ensures that a polluting region gains relatively less from an IEA than the country as a whole, it achieves that the interest of the country's regional negotiators in abatement is lower than that of the federal government. Thereby, the constitutional and accompanying political decisions strengthen the country's bargaining position. But, since both countries face the same incentives to delegate the bargaining power to the regional government and to implement a 'distortionary' grant scheme, their attempts to be at an advantage in the negotiations neutralize each other. Moreover, the resulting IEA sets inefficiently low abatement targets from the perspectives of the countries as a whole exactly because the federal governments strategically depress the bargaining incentives of the negotiators.²

Our conclusions are in contrast to the results in Eckert (2003). She also considers how the distribution of power in a state affects the outcome of an IEA. But she concludes that the delegation of bargaining power to the regional level might or might not be an optimal strategy for a country, while we argue that this kind of delegation is always the best choice. The ambiguity of her results are basically caused by a lack of instruments. In her framework, the federal governments have no matching grants or other transfers at their disposal. Thus, a country is left only with a discrete delegation choice between the federal and the regional government. In this case, it might abstain from delegating the decision to regional negotiators if their interests differ too much from those of the federal authorities. By contrast, if

²Note that the reason for the ineffectiveness of an IEA in the present context is very different from that in non-cooperative approaches to international negotiations. Barrett (1994), for instance, shows that IEAs fail to be efficient in most instances because self-enforcing agreements do often not support a large number of signatory countries. By contrast, in the current framework negotiations lead to suboptimal abatement levels because the bargaining authority is delegated to regional governments whose interests differ from those of the country as a whole.

the federal government can fine tune the incentives of the regional government by means of a suitable grant scheme as in our model, a decentralized solution is always optimal. So one major difference between our approach and that of Eckert (2003) is that our framework incorporates a richer set of instruments. We will come back to this issue below. A further, technical difference is that we construct a model that enables us to derive all results analytically, while Eckert (2003) partly relies on simulations.

The present analysis is also particularly related to the literature on delegation in bargaining processes. Segendorff (1998) and Buchholz et al. (2005) analyze negotiations between two countries over the provision of a pure international public good and over cuts in transboundary pollution, respectively. Both papers stress the incentives to strategically delegate bargaining power to agents who pay less attention to environmental quality than the delegating ‘authority’.³ However, they ignore the role of constitutional choices in federal systems as an indirect delegation device.

The paper is organized as follows: We describe the basic relationship between abatement costs and benefits, and present the timing of the sequential decisions in section 2. The outcome of Nash bargaining is provided in section 3. We analyze the constitutional and political choices preceding the international negotiations in section 4. In this section, we also explore the entire equilibrium. In the section 5, we further examine the role of constitutional and political choices as devices to strategically delegate the authority to negotiate an IEA. We summarize our results and discuss some political implications in the concluding section.

2 Regions, Constitutions, and the Environment

In this section, we present our stylized model that enables us to outline the interplay between the constitutional and political choices on the one hand and the succeeding international environmental negotiations on the other hand. We consider a two-country world where environmental externalities between the regions within a country and between the countries occur. While the federal government can in principle adopt suitable measures so that the environmental spillovers between the domestic regions are internalized, no authority that could do the same on the international stage exists. The spillovers between regions of different countries

³The basic idea – that in misrepresenting the own preferences, an individual can raise her payoff in a bargaining solution – was developed in the seminal contributions by Crawford and Varian (1979), Sobel (1981), and Burtraw (1992). In an environmental context, Hoel (1991) argues that a country which acts as if it were eco-friendlier than it really is reduces the payoff it receives in the bargaining solution. He does, however, not relate this finding to delegation or other mechanisms that enable a country to commit itself to a strategy which in conflict with its true objectives.

can only be tackled by means of an IEA. The decision process outlined below models not only the international negotiations, but also the preceding constitutional and political choices in the two countries that substantially affect the succeeding IEA. These preceding decisions encompass a constitutional and a political choice. In the constitutional stage, the power to decide on abatement levels and to negotiate on an IEA is assigned to the federal governments or to the governments of the polluting regions. For brevity, we refer to these two alternatives as centralized and decentralized system, respectively. In the political stage, grants that distribute the abatement benefits and burdens within a country are decided on. Afterward, Nash bargaining between the governments in charge of negotiations over abatement levels takes place.

2.1 Abatement Costs, Benefits, and Grants

Consider two neighboring countries 1 and 2, which are symmetric in every respect. Each of them consists of two regions. To take into account the fact that ‘dirty’ industries are unevenly distributed, in each country the pollution is assumed to be generated only in one of the two regions. It, however, damages the environment in all areas of the same country and abroad. Consequently, the benefits of abatement activities that reduce this transboundary pollution are spread over all four regions. By contrast, the costs of abatement only occur in the polluting regions.

For instance, think of a fishing industry which is located in the countries’ coastal areas. While these regions bear the costs of tougher regulations, the whole population in the two countries benefits from the protection of species and the resulting maintenance of biodiversity. Further examples are the carbon mining industry and the nuclear power stations along the upper course of a river. Acid waste water and the waste heat can be only avoided in the upstream areas where the mines and cold-storage plants are located. The benefits of abatement, however, also arise in the regions downstream.

Denote by $g_i \geq 0$ the abatement costs in the polluting region of country i . The abatement activities positively affect the environment in both countries. A positive, twice-continuously differentiable and strictly concave function $B_i = B(g_i + sg_j)$ relates country i ’s abatement benefits B_i to the abatement costs g_i and g_j in country i ’s and j ’s polluting regions. This benefit function is bounded from above and fulfills the Inada-type conditions $\lim_{g_i+sg_j \rightarrow 0} B'(\cdot) = \infty$ and $\lim_{g_i+sg_j \rightarrow \infty} B'(\cdot) = 0$. The parameter s denotes the international spillover. We assume that $s \in (0, 1)$ holds, i.e. that abatement in i ’s polluting region contributes more to a cleaner environment in country i than in country j .⁴

⁴Note that the upper bound of the interval $(0, 1)$ covers the case of the environment as a pure international public good.

B_i measures the abatement benefits of the entire population in country i in monetary terms. Thus, country's net benefits are given by

$$NB_i^F = B(g_i + sg_j) - g_i. \quad (1)$$

The superscript ' F ' stands for federal government, which represents the country as a whole.

Since only a part of the population resides in the polluting region, this region receives only a part of the total benefit B_i . Denoting this share by $\alpha \in (0, 1)$, the benefit of the polluting region is equal to αB_i . Moreover, this region might receive transfers, since in the case of a decentralized system the federal government could be interested in shaping the incentives of the polluting region by providing grants. As there are only two regions in each country, any grants are equivalent to an centrally imposed transfer from the 'clean' to the 'dirty' region. In the current context, these grants can be related to two figures, the abatement costs and the resulting benefits. We consider both possibilities. The polluting region might receive a matching grant $m_i g_i$, which covers part of the regional abatement costs, and a benefit-related grant $\beta_i B_i$. In any case, $m_i, \beta_i \geq 0$ is assumed to hold.

Taking these transfers into account, the net benefits of the polluting region is given by

$$NB_i^R = (\alpha + \beta_i) B(g_i + sg_j) - (1 - m_i) g_i, \quad (2)$$

where ' R ' stands for that region's government, which represents the local population.

2.2 Constitutional Design, Political Choices, Bargaining

A three-stage decision process models not only the international negotiations, but also the potential preceding constitutional and political choices that shape the outcome of the IEA. In the first stage (*constitutional stage*), the federal governments of the two countries non-cooperatively decide whether the power to determine the abatement levels in the polluting regions and the power to negotiate over an IEA stay with them or lie with the governments of the polluting regions. We refer to these two distinct arrangements as centralized and decentralized systems, respectively.⁵ Making this constitutional decision, each federal government takes the strategy of its opponent as given and chooses the solution that maximizes its payoff.

If the decentralized system is adopted in a country, the government of the polluting region irrevocably decides on the abatement activities. In this case, only the

⁵These constitutional choices cannot be revoked, at least not within the relevant time horizon. So they imply a perfect commitment of the country. In this respect, our approach differs from models in which principles can revoke their partial commitments later at some costs. See, for instance, Muthoo (1996).

regional government can sign a binding IEA. The federal government, however, can still influence the bargaining incentives of the regional authority by implementing a grant scheme. As described above, the federal government has a matching grant and benefit-related grant at its disposal. Thus, in the second stage (*political stage*) it decides on the rates m_i and β_i .

After the decision on the constitutional and political bargaining framework have been made in the two countries, the international negotiations can start. In the third stage (*bargaining stage*), the two governments in charge of environmental negotiations bargain over the abatement levels and potential side payments between them. The outcome of these negotiations is described by the Nash bargaining solution. This solution substantially depends on the threat point, i.e. the outcome that would be realized if negotiations failed. In that case, the governments which are responsible for environmental policy set the abatement levels simultaneously and non-cooperatively. The resulting solution of this Nash game serves as a threat point for the negotiations.

The following table summarizes the sequence of decisions:

Stages	Decisions
1. Constitutional stage	Governments in charge of negotiations, F or R
2. Political stage	Grant scheme m_i and β_i
3. Bargaining stage	IEA: abatement levels g_1 and g_2 (and side payments)

Table 1: Sequence of Decisions

2.3 Centralization versus Decentralization

A closer look at the net benefits (1) and (2) shows that for the grant rates $m_i = 0$ and $\beta_i = 1 - \alpha$, the objective functions of the federal and the regional governments coincide. In this case, the regional government has the same bargaining incentive as the federal government; in fact, the regional government would act as if it were the federal government. Consequently, the Nash bargaining solution for the decentralized system and the rates $m_i = 0$ and $\beta_i = 1 - \alpha$ replicates that for the centralized system. In this sense, the centralized solution can be considered as a special case of the decentralized one.

This relationship between the two constitutional designs simplifies the following analysis considerably. Conducting the usual backward induction, we do not need to distinguish between the centralized and decentralized system explicitly. Instead, we can simply analyze the second and third stage of the game for the case of a decentralized solution. If $m_i \neq 0$ or $\beta_i \neq 1 - \alpha$ results in the second stage, the decentralized system is indeed the equilibrium choice. Then, the optimal negotiator

should have bargaining incentives that differ from those of the federal government. This can only be achieved by means of decentralization. By contrast, if the outcome is $m_i = 0$ and $\beta_i = 1 - \alpha$ in the political stage, then the federal government would be the optimal negotiator for the country. In this case, there is no need for decentralization.

3 International Environmental Agreements

Applying backward induction, we first turn to the bargaining solution in the third stage. Since the non-cooperative abatement levels, which are implemented if the negotiations fail, determine the threat point, they have to be solved for first. Afterward, we provide the Nash-bargaining solution and show how this outcome is related to countries' grant schemes. These results are the prerequisites for our analysis of the constitutional and political decisions in section 4.

3.1 Threat Point

Let us explore the strategies of the governments in charge of environmental policy when abatement levels are determined non-cooperatively. In this case, the two governments carry out their optimal policy, taking the strategy of the rival as given and ignoring the externalities of their policies. Country i 's responsible government chooses the level g_{in} that maximizes its net benefits

$$NB_i^R = (\alpha + \beta_i) B(g_{in} + sg_{jn}) - (1 - m_i) g_{in}, \quad (3)$$

where the additional subscript n indicates the abatement levels adopted in the non-cooperative case. We obtain the first-order condition⁶

$$(\alpha + \beta_i) B'_{in} = 1 - m_i. \quad (4)$$

It says that *from the perspective of country i 's government in charge of environmental policy*, marginal abatement benefits equal marginal abatement costs in optimum. If the responsibility for the abatement levels lies with the federal government (i.e. if $m_i = 0$ and $\beta_i = 1 - \alpha$), these figures coincide with the marginal benefits and costs of the country as a whole. By contrast, if the government of the polluting region is in charge, condition (4) only captures the marginal benefits and costs that accrue to this region.

⁶ B'_{in} denotes the value of the derivative of region i 's benefit function $B(\cdot)$ with respect to $g_{in} + sg_{jn}$ in case of non-cooperatively acting governments.

The first-order condition (4) implicitly determines the reaction curves and the unique Nash equilibrium. If the grant schemes in the two countries are not too different, an interior solution $g_{in}(\gamma_i, \gamma_j) = [B'^{-1}(\gamma_i) - sB'^{-1}(\gamma_j)] / (1 - s^2) > 0$, where $\gamma_i = (1 - m_i) / (\alpha + \beta_i)$, results.⁷ The threat point (g_{1n}, g_{2n}) and thus the bargaining solution obviously depend on the two countries' grant rates $m = (m_1, m_2)$ and $\beta = (\beta_1, \beta_2)$. Since these connections offer an opportunity for the federal governments to influence the outcome of an IEA, we are interested in the comparative statics of these variables. Using first-order condition (4), we obtain

$$\frac{\partial g_{jn}}{\partial \beta_i} = -s \frac{\partial g_{in}}{\partial \beta_i} = \frac{s(1 - m_i)}{(1 - s^2)(\alpha_i + \beta_i)^2 B''_{in}} = \frac{1 - m_i}{\alpha + \beta_i} \frac{\partial g_{jn}}{\partial m_i} = -s \frac{1 - m_i}{\alpha + \beta_i} \frac{\partial g_{in}}{\partial m_i} < 0. \quad (5)$$

A larger rate m_i or β_i increases country i 's abatement level in the threat point while country j 's polluting region reduces its effort. The intuition for this conclusion is straightforward. A higher matching or benefit-related grant raises the marginal benefits of i 's responsible government relative to its abatement costs. Abatement becomes more attractive, and the level g_{in} increases. As a consequence of a strictly concave benefit function and less pollution generated in country i , j 's benefits from its own abatement activities decline. In response, j 's government holding regulatory power reduces its abatement level g_{jn} . In other words, the countries' choice variables are strategic substitutes like in the standard problem of a non-cooperative private provision of public goods. Overall, the environment becomes cleaner in country i while it is unchanged in country j , i.e. $\partial(g_{in} + sg_{jn})/\partial m_i > 0$, $\partial(g_{in} + sg_{jn})/\partial \beta_i > 0$, $\partial(g_{jn} + sg_{in})/\partial m_i = 0$ and $\partial(g_{jn} + sg_{in})/\partial \beta_i = 0$ holds.⁸

3.2 Bargaining over Abatement and Side payments

The equilibrium of the previous section provides the countries' abatement levels if environmental policies are decided non-cooperatively. This solution determines the threat point of the negotiations over an IEA. To give the outcome of these negotiations, we apply the concept of the Nash-bargaining solution. We also take account of the fact that agreements on environmental issues are frequently accompanied by (implicit) side payments between countries.⁹ Thus, any negotiations contain two issues, abatement levels and potential side payments.

⁷Formally, this requires $s < \min \{B'^{-1}(\gamma_1)/B'^{-1}(\gamma_2); B'^{-1}(\gamma_2)/B'^{-1}(\gamma_1)\}$ to hold. Otherwise, $g_{in}(\gamma_i) = B'^{-1}(\gamma_i)$ and $g_{jn} = 0$ result in equilibrium for $\gamma_j > \gamma_i$. In any case, the equilibrium is unique (cf. Buchholz et al. 2005). Moreover, in section 4 we argue why focusing on an interior solution makes indeed sense.

⁸The latter conclusion follows from the quasi-linear preferences.

⁹The Kyoto Protocol on the emission of substances that cause global warming provides an example for the incorporation of international transfers into an IEA. We think it is fair to say that implicit side payments are granted through 'generous' grandfathering of certificates to Russia and

The calculation of the Nash-bargaining solution with side payments is straightforward. The negotiating governments first choose the abatement levels that maximize their aggregate payoff. (Recall that abatement costs as well as benefits are measured in monetary units.) Afterward, a side payment from one government to the other is determined such that the two negotiating parties receive the same absolute payoff increase relative to the threat point.¹⁰

The resulting abatement levels g_{1c} and g_{2c} are efficient from the perspective of the negotiating governments. They maximize their aggregate payoff

$$AP = \sum_{i=1}^2 [(\alpha + \beta_i) B(g_{ic} + sg_{jc}) - (1 - m_i) g_{ic}], \quad (6)$$

where the subscript c indicates the cooperative case. If the federal governments negotiate (i.e. if $m_i = 0$ and $\beta_i = 1 - \alpha$), this objective coincides with the ‘true’ benefits and costs of the two countries together. By contrast, if the government of a polluting region takes part in the negotiations, only its regional abatement costs and benefits including grants enter the objective AP .

Since this aggregate payoff is strictly concave, a unique solution to the allocation problem (6) exists. The optimal abatement levels are implicitly given by the first-order conditions

$$(\alpha + \beta_1) B'_{1c} + s(\alpha + \beta_2) B'_{2c} = 1 - m_1 \text{ and} \quad (7)$$

$$s(\alpha + \beta_1) B'_{1c} + (\alpha + \beta_2) B'_{2c} = 1 - m_2. \quad (8)$$

The left-hand sides (LHSs) of these conditions capture the *aggregate* marginal benefits of the abatement in country 1 and 2, respectively. The right-hand sides (RHSs) give the corresponding marginal costs. Trivially, marginal abatement costs are equal to the generated aggregate marginal benefits of the two negotiating parties in the cooperative solution.

In the ensuing analysis, we refer to the first-order conditions (7) and (8) as well as to two equations which follow from inserting (8) into (7) and vice versa:

$$(\alpha + \beta_1) B'_{1c} = \frac{1 - m_1 - s(1 - m_2)}{1 - s^2} \text{ and} \quad (9)$$

other countries. Selling these certificates on the world market generates transfer-like revenues for these regions. The role of such side payments is already discussed in Chichilnisky and Heal (1994) and Eyckmans, Prost and Schokkaert (1993).

¹⁰Using Nash bargaining with appropriate side payments simplifies the analysis significantly. Similar results as in the current framework can be obtained when the modelling approach to negotiations applies the outside option principle. Then, threat points do not play any role in case of symmetric countries. Such a kind of modelling reduces the complexity of the economic structure in a similar way as side payments do.

$$(\alpha + \beta_2)B'_{2c} = \frac{1 - m_2 - s(1 - m_1)}{1 - s^2}. \quad (10)$$

In contrast to its counterpart in the non-cooperative case (4), the spillover parameter s explicitly appears in the conditions (9) and (10), since the impact of a country's abatement activities on the other negotiating party is now taken into account.

If at least one regional government is involved in the negotiations (i.e. if $m_i \neq 0$ or $\beta_i \neq 1 - \alpha$ holds for at least one country), the resulting abatement levels depend on the grant rates. As a prerequisite of exploring the optimal grant schemes from the perspective of a federal government and the question of whether a federal government decentralizes power at all, we analyze the impact of these schemes on the IEA in more detail.

Let us first turn to the relationship between the abatement levels (g_{ic}, g_{jc}) and the rates (β_i, β_j) . Usual comparative statics yields

$$\frac{\partial g_{jc}}{\partial \beta_i} = -s \frac{\partial g_{ic}}{\partial \beta_i} = \frac{sB'_{ic}}{(\alpha_i + \beta_i)B''_{ic}} < 0, \quad (11)$$

which implies

$$\frac{\partial (g_{ic} + sg_{jc})}{\partial \beta_i} = (1 - s^2) \frac{\partial g_{ic}}{\partial \beta_i} = -\frac{(1 - s)^2 B'_{ic}}{(\alpha_i + \beta_i)B''_{ic}} > 0 \text{ and } \frac{\partial (g_{jc} + sg_{ic})}{\partial \beta_i} = 0. \quad (12)$$

A higher benefit-related grant rate in, say, country 1 increases the marginal benefits from abatement for the government of 1's polluting region (see LHS of (9)). In response, the optimal level $g_{1c} + sg_{2c}$ rises (see (12)). By contrast, 2's marginal benefits and thus the optimal level $g_{2c} + sg_{1c}$ remain unaltered as long as all other grant rates stay constant (see (10) and (12)). This outcome can only be achieved if the abatement level g_{1c} is raised and the level g_{2c} is lowered, as expressed in (11).

A similar line of reasoning explains the more complicated relationships between the optimal policies (g_{ic}, g_{jc}) and the matching grant rates (m_i, m_j) , which are given by

$$\frac{\partial g_{ic}}{\partial m_i} = -\frac{(\alpha + \beta_j)B''_{jc} + s^2(\alpha + \beta_i)B''_{ic}}{(\alpha + \beta_i)B''_{ic}(\alpha + \beta_j)B''_{jc}(1 - s^2)^2} > 0 \text{ and} \quad (13)$$

$$\frac{\partial g_{jc}}{\partial m_i} = \frac{s [(\alpha + \beta_i)B''_{ic} + (\alpha + \beta_j)B''_{jc}]}{(\alpha + \beta_i)B''_{ic}(\alpha + \beta_j)B''_{jc}(1 - s^2)^2} < 0. \quad (14)$$

These results of comparative statics lead to

$$\frac{\partial (g_{ic} + sg_{jc})}{\partial m_i} = -\frac{1}{(\alpha + \beta_i)B''_{ic}(1 - s^2)} > 0 \text{ and} \quad (15)$$

$$\frac{\partial (g_{jc} + sg_{ic})}{\partial m_i} = \frac{s}{(\alpha + \beta_j)B''_{jc}(1 - s^2)} < 0. \quad (16)$$

In the case of a matching grant, a higher rate in, say again, country 1 cuts the marginal costs of abatement for 1's polluting region. Abatement activities in this region become more attractive. In optimum, they increase as expressed in (13) so that the induced aggregate marginal benefits of the two negotiating parties fall to the lower marginal cost level (see (7)). At the same time, the aggregate marginal benefits generated by 2's abatement activities have to stay constant in optimum as long as the corresponding costs for 2's polluting region remain unchanged (see (8)). Thus, to restore the optimum after an increase in the rate m_1 , the level $g_{1c} + sg_{2c}$ has to be raised and its counterpart $g_{2c} + sg_{1c}$ has to be lowered (see (15) and (16)). To achieve both ends, g_{2c} is reduced (see (14)) while g_1 is increased (see (13)).

To sum up, both a higher benefit-related grant and a higher matching grant for i 's polluting region shift the abatement activities from country j to country i in the cooperative solution. Thus, the total abatement costs of country i go up. This broad picture remains valid if side payments are included, as a closer look on them shows. Since the gains from cooperation are split equally between the two negotiating parties, side payments S_i from i 's government to its opponent in the negotiations are given by

$$S_i = \frac{1}{2} \left\{ \underbrace{\left[((\alpha + \beta_i)B_{ic} - (1 - m_i)g_{ic}) - ((\alpha + \beta_i)B_{in} - (1 - m_i)g_{in}) \right]}_{\text{gains of } i\text{'s negotiating government from cooperation}} - \underbrace{\left[((\alpha + \beta_j)B_{jc} - (1 - m_j)g_{jc}) - ((\alpha + \beta_j)B_{jn} - (1 - m_j)g_{jn}) \right]}_{\text{gains of } j\text{'s negotiating government from cooperation}} \right\} \quad (17)$$

where B_{ic} and B_{in} denote country i 's benefits in the cooperative solution and in the non-cooperative threat point, respectively. In the current model, the transfer paid by one of the negotiating governments equals the payments received by the other, i.e. $S_i = -S_j$.

The marginal impact of an increase in the benefit-related grant rate β_i on country i 's total abatement costs including side payments amounts to

$$\frac{\partial (S_i + g_{ic})}{\partial \beta_i} = \frac{B_{ic} - B_{in}}{2} + \frac{\rho_j s}{2} \frac{\partial g_{in}}{\partial \beta_i} + [1 - s(1 - m_j)] \frac{\partial g_{ic}}{\partial \beta_i}, \quad (18)$$

where $\rho_j = 1 - m_j + s(1 - m_i)$. The terms in (18) show the different mechanisms at work. First, for constant abatement levels a higher grant increases the difference between the benefits of i 's polluting region in the cooperative solution and in the non-cooperative one. Since i 's gains from abatement rise, larger payments to the other side are accepted. This effect is reflected in the positive first term on the RHS of (18).¹¹ Second, a rise in the grant rate β_i increases the regional government's

¹¹The benefits in the cooperative solution are indeed larger than in the non-cooperative solution.

willingness to conduct more abatement activities in both the cooperative and the non-cooperative case. Since this weakens the government's bargaining position, it increases i 's total costs including side payments in the cooperative outcome. This effect is captured in the second and the third term, which are both positive. All in all, a country's total costs of abatement (including side payments) rise in response to a higher benefit-related grant.

A similar result can be obtained with respect to a matching grant:

$$\frac{\partial (S_i + g_{ic})}{\partial m_i} = \frac{(g_{ic} - g_{in})}{2} + \frac{\rho_j s}{2} \frac{\partial g_{in}}{\partial m_i} + \left(1 - \frac{\eta_j s}{1 - s^2}\right) \frac{\partial g_{ic}}{\partial m_i} + \frac{\eta_i s}{1 - s^2} \frac{\partial g_{jc}}{\partial m_i}, \quad (19)$$

where $\eta_i = 1 - m_i - s(1 - m_j)$ and $\eta_j = 1 - m_j - s(1 - m_i)$. Albeit there are differences in detail, the basic effects of a higher matching grant are the same as in the case of a higher benefit-related grant. If i 's rate m_i goes up, the non-cooperative abatement activities are shifted again from country j to country i . This adjustment weakens the threat point of i 's negotiators, which in turn drives its side payments up. The positive second term of the RHS captures this effect. Moreover, a matching grant shifts the abatement burden in the bargaining solution from country j to country i . While this effect reduces i 's bargaining gains and thus its side payments, it increases i 's immediate abatement costs. Since this immediate impact on abatement costs always dominates secondary effects on side payments, total costs including the international transfers rise. Formally, this means that the sum of the last two terms is also positive.¹² Finally, a higher matching grant cuts abatement costs in the cooperative outcome compared to the non-cooperative equilibrium if the abatement level is higher in the former than in the latter case (i.e. if $g_{ic} > g_{in}$ holds). Then, i 's gains from an IEA increase in the grant rate, and thus side payments to j 's negotiator rise. This effect is reflected in the first term of the RHS.

4 Constitutional Choice and Grant Schemes

If the federal government chooses the decentralized solution in the first stage, it can implement a matching and a benefit-related grant in the second stage. The grant scheme are used to fine tune the bargaining incentive for the country's regional

To see this, note that the following relationships are implied by the concavity of the benefit function and the conditions (4), (9) and (10): $B_{ic} > B_{in} \Leftrightarrow B'_{ic} > B'_{in} \Leftrightarrow [1 - m_i + s(1 - m_j)] / (1 - s^2) = 1 - m_i \Leftrightarrow 1 - m_j + s(1 - m_i) > 0$. The last inequality is fulfilled as long as an interior solution exists and thus the RHSs of (9) and (10) are positive.

¹²This follows from inserting (13) and (14) into $[1 - (\eta_j s / (1 - s^2))] (\partial g_{ic} / \partial m_i) + (\eta_i s / (1 - s^2)) (\partial g_{jc} / \partial m_i)$, which leads to $[(1 - s^2) (\alpha + \beta_i) (\alpha + \beta_j) B''_{ic} B''_{jc}]^{-1} \{-s^2 m_i (\alpha + \beta_i) B''_{ic} - [1 - s(1 - m_j)] (\alpha + \beta_j) B''_{jc}\} > 0$.

government so that the regional negotiators optimally pursue the goal of the country as a whole. Making its choice on the rates m_i and β_i , i 's non-cooperatively acting federal government takes the other country's negotiating party and, if this is the regional government too, the grant scheme abroad as given.

No matter whether the other side's negotiating party is the federal or the regional government of that country, its representatives are completely described by the rates β_j and m_j . As already explored above, centralization can only be optimal if $\beta_i = 1 - \alpha$ and $m_i = 0$ result. Otherwise, decentralization is i 's best strategy.

When choosing the optimal grant scheme for region i , the federal government considers the abatement benefits and costs for the country as a whole including potential side payments in connection with an IEA. Thus, its payoff is given by

$$P_i^F = NB_i^F - S_i = B(g_{ic}(\beta, m) + sg_{jc}(\beta, m)) - g_{ic}(\beta, m) - S_i(\beta, m), \quad (20)$$

where $\beta = (\beta_i, \beta_j)$ and $m = (m_i, m_j)$.

The federal government indirectly affects the final abatement outcome (g_{1c}, g_{2c}) and the side payments S_i via its choice of the grant rates m_i and β_i . Analyzing the optimal scheme, we first focus on interior solutions, but discuss the possibility of boundary solutions later. Moreover, we concentrate on symmetric equilibria, since the two countries are identical in every respect.

In the case of an interior solution, the optimal grant rates are characterized by the first-order conditions

$$B_{ic}' \frac{\partial (g_{ic} + sg_{jc})}{\partial \beta_i} = \frac{\partial (S_i + g_{ic})}{\partial \beta_i} \text{ and} \quad (21)$$

$$B_{ic}' \frac{\partial (g_{ic} + sg_{jc})}{\partial m_i} = \frac{\partial (S_i + g_{ic})}{\partial m_i}. \quad (22)$$

In optimum, the grants balance two opposing effects already indicated by the comparative statics in the previous section. On the one hand, both a higher matching grant and a higher benefit-related grant indeed increase the level $g_{ic} + sg_{jc}$ and, therefore, country i 's abatement benefits (LHSs), since they provide additional incentives for domestic pollution cuts. On the other hand, total costs $S_i + g_{ic}$ increase in equilibrium (RHSs), since the grants weaken the country's bargaining power.

Inserting (12) and (18) into (21), we obtain

$$\begin{aligned} \frac{\partial g_{ic}}{\partial \beta_i} \left[\frac{1 - m_i - s(1 - m_j)}{\alpha_i + \beta_i} - [1 - s(1 - m_j)] \right] = \\ \frac{1}{2} \left\{ B_{ic}' - B_{in}' + s[1 - m_i + s(1 - m_j)] \frac{\partial g_{in}}{\partial \beta_i} \right\} > 0 \end{aligned} \quad (23)$$

As the RHS of (23) is positive, in equilibrium the LHS has to be positive too. This implies that the inequalities $\alpha + \beta_i < [1 - m_i - s(1 - m_j)] / [1 - s(1 - m_j)] \leq 1$ have to be satisfied. Since $\beta_i > 1 - \alpha$ results, a benefit-related grant only partly internalizes the externalities between the domestic regions. To put it differently, the federal government prefers a negotiator that never reaps the full domestic abatement benefits. As an immediate consequence of this conclusion, choosing a decentralized system is a dominant strategy in the constitutional stage. It can never be optimal that the power to negotiate an IEA lies with the federal government in each country.

To fully assess the implications of this result, we establish the relationship between the benefit-related grant and the matching grant in equilibrium. Using (19) to rearrange (22) yields

$$\frac{\partial g_{ic}}{\partial m_i} \left[\frac{1 - m_i - s(1 - m_j)}{(1 - s^2)(\alpha_i + \beta_i)} + \frac{s[1 - m_i - s(1 - m_j)]}{1 - s^2} - 1 \right] = \frac{1}{2} \left\{ g_{ic} - g_{in} + s[1 - m_i + s(1 - m_j)] \frac{\partial g_{in}}{\partial m_i} \right\} - s \frac{\partial g_{jc}}{\partial m_i} [1 - \alpha_i - \beta_i] B'_{ic} > 0. \quad (24)$$

Since $\alpha + \beta_i < 1$ follows from (23), the RHS of (24) is positive in a symmetric equilibrium.¹³ Thus, first-order condition (24) can be only fulfilled if the LHS is also positive, which means that the inequality $1 - m_i > \alpha + \beta_i$ has to hold. Although the matching grant covers a part of the abatement costs, the polluting region's share of the domestic abatement costs $1 - m_i$ is larger than its share of the domestic benefits $\alpha + \beta_i$. In this sense, there is no 'fair' cost sharing, i.e. the financial burdens associated with the pollution cuts are more than proportionally born by the polluting regions of the two countries.

In this way, each country delegates bargaining power to a negotiator whose net gains from a cleaner environment are lower than that of the federal government. This strategy depresses the willingness of the negotiating regional government to accept financially painful domestic abatement levels. Since it strengthens the country's bargaining power, the costs of an environmental improvement upon the non-cooperative solution are shifted to the other country.

This cost-shifting effect explains why countries have incentives to put regional governments in charge of environmental policy and negotiations. But why should, from a country's perspective, this constitutional choice be accompanied by a grant scheme? The answer to this question is straightforward: Regional governments might care 'too little' for the environment. Note that the bargaining solution maximizes, by definition, the aggregate payoff of the two negotiating regional govern-

¹³Note that, in the symmetric case, $B'_{ic} > B'_{in}$ directly implies that $g_{ic} > g_{in}$ for $i = 1, 2$. Thus, the terms in the first bracket of RHS of (24) are positive.

ments. Since they underestimate the ‘true’ payoff gains from abatement, the pollution cuts agreed on in the IEA are suboptimally low from the perspective of the country as a whole. This negative lack-of-effectiveness dominates the positive cost-shifting effect if the payoff function of the polluting region differs too much from that of the federal government. To balance these two opposing effects, the regional interests have to be sufficiently aligned with the federal ones. This goal can be achieved by means of benefit-related grants and matching grants, which fine tune the bargaining incentives of the regional government.

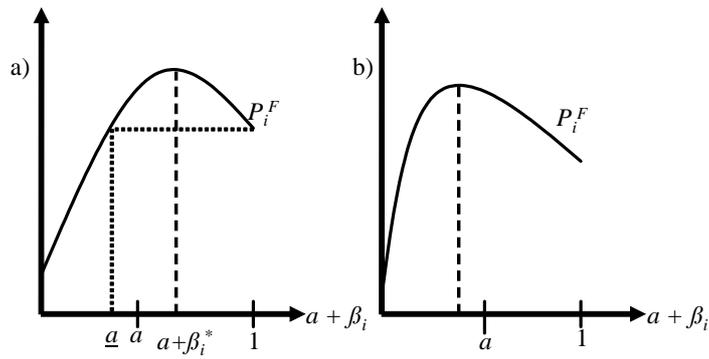


Figure 1: Delegation and Benefit Share

Figure 1 a) and b) illustrate this result. The graphs show the relationship between the federal government's payoff P_i^F and polluting region's benefit share $a + \beta_i$ for a given policy abroad. (For simplicity, assume that the rate m_i is fixed at zero.) In figure 1 a), the maximum is reached if rate β_i^* is implemented. By contrast, a ‘pure’ decentralization, i.e. decentralization without an accompanying grant, is optimal from the country's perspective in the case drawn in figure 1 b). In this situation, a boundary solution results, since the payoff function of the regional government is already too similar to that of the federal government. If a negative grant is excluded, the best the federal government can do is to set the rate β_i equal to zero.¹⁴ A similar line of reasoning holds for the matching grant.¹⁵ Thus, an interior solution requires a sufficiently small parameter α . To sum up:

¹⁴Formally, this means that the LHS of (23) is already smaller than the RHS for $\beta_i = 0$.

¹⁵While we cannot exclude a ‘lower boundary solution’ $m_i = 0$ or $\beta_i = 0$, we can neglect ‘upper boundary solutions’. Our preceding analysis already indicates that the outcome $m_i = 1$ cannot be an equilibrium. In this case, the regional government would not bear any abatement costs, and it would thus abate as much as possible (see first-order conditions (7) and (8)). Since benefits are bounded, such a strategy cannot be optimal, even if parts of the costs were offset by side payments.

Proposition 1 *Constitutional Choices and Grant Schemes.*

i) *In the constitutional stage, each federal government's dominant strategy is to put the government of its polluting region in charge of environmental policy and negotiations.*

ii) *If a strictly positive benefit-related grant or matching grant is implemented, the scheme has two properties. First, the benefit-related grant only partly internalizes the domestic abatement externalities, i.e. $\alpha + \beta_i^* < 1$ holds. Second, in a symmetric equilibrium the polluting region's share of abatement costs exceeds its share of abatement benefits including the benefit-related grant, i.e. $1 - m^* > \alpha + \beta^*$ results.*

Proof. See explanations in this section. ■

Both countries delegate the power to negotiate an IEA to regional governments without providing sufficient incentives for them to internalize the international externalities. Thereby, the federal governments also relinquish the internalization of the domestic externalities in order to gain a strategic advantage in the international negotiations. But the attempts of both countries to shift the costs of an IEA to the other side neutralize each other. The federal governments end up in a prisoners' dilemma. In a symmetric equilibrium, the only lasting effect is that the abatement levels agreed on are suboptimally low from the perspective of the two countries as a whole. The IEA is ineffective, although it maximizes the aggregate payoff of the negotiators, since the countries' free-riding behavior is simply shifted from the level of the negotiations to that of the preceding constitutional and political decisions.

Proposition 2 *Ineffectiveness of the IEA.*

In a symmetric equilibrium, the abatement activities are too low from the perspective of the countries as a whole. The countries' aggregate payoff would rise if the two federal governments were in charge of environmental policy and negotiations.

Proof. In a symmetric equilibrium, the two countries make identical choices. Hence, $B'(g_c^*(1+s)) = (1-m^*)/(\alpha+\beta^*)(1+s) > 1/(1+s) = B'(g_{FF}(1+s))$, where g_{FF} denotes each country's abatement level in case in which the federal governments negotiate with each other and g_c^* refers to the abatement level in the subgame-perfect equilibrium. Note that g_{FF} is also the symmetric abatement level that maximizes each country's payoff $B(g_{FF}(1+s)) - g_{FF}$. (Side payments do not appear in the payoff, since they are equal to zero in a symmetric solution.) Since the benefit

For similar reasons, 'too' large rates β_i can be also ignored. Since the solution has to contain rather 'moderate' schemes, the relevant intervals of the rates are reasonably assumed to generate interior solutions (g_{ic}, g_{jc}) and (g_{in}, g_{jn}) in the third stage so that we can apply the usual comparative statics.

function $B(\cdot)$ is strictly concave, $B'(g_c^*(1+s)) > B'(g_{FF}(1+s))$ directly implies the inequalities $g_c^* < g_{FF}$ and thus $P^F(g_{FF}) > P^F(g_c^*)$. ■

5 Constitution and Strategic Delegation

The conclusion of the previous section is clear: Decentralization is a dominant but ultimately harmful strategy for both countries. This outcome deviates from Eckert's (2003) findings. In her setting, decentralization might but need not necessarily be the best strategy of a country. Whether the federal governments empower the subordinated regional governments to decide on environmental policy and negotiate an IEA depends on the regional benefit share α .

The difference between her and our framework is that she only considers the constitutional choice and ignores accompanying political instruments like grants. If the set of possible instruments is constrained in that way, the constitutional decision is not a priori clear. As explored above, the lack-of-effectiveness can outweigh the cost-shifting effect in the case of 'pure' decentralization. This situation is illustrated in figure 1a). As long as the share α falls short of the threshold $\underline{\alpha}$, the payoff is larger in the centralized solution than the 'purely' decentralized solution, i.e. $P_i^F(1) > P_i^F(\alpha)$. Left with the two extreme solutions as the only choices, the federal government prefers to centralize political power, and in the case of a symmetric equilibrium the IEA establishes the countries' first-best solution. By contrast, if the government has sufficient instruments at its disposal, decentralization emerges as dominant strategy, and environmental agreements are suboptimal from the perspective of the federal governments. In this sense, our conclusion is much stronger and more worrying than that in Eckert (2003).

It is, however, in line with recent contribution on negotiations over the provision of public goods in general or environmental quality in particular. Segendorff (1998) and Buchholz et al. (2005) show that a country's 'authority' gains from delegating the bargaining power to an 'agent' who pays less attention to the environment than the 'authority' itself.¹⁶ In the political-economics approach in Buchholz et al.

¹⁶In contrast to these two papers, Siqueira (2003) argues that the preferences of the delegated agents are consistent with that of the principals if countries cooperatively determine their policy in the context of international externalities. This difference partly arises because Siqueira (2003) uses a very different notion of cooperation. He focuses on an economic and political integration, i.e. the two governments become a single decision unit. By contrast, Segendorff's, Eckert's and our solutions are based on Nash bargaining, which encompasses more than maximizing aggregate payoff. (See Muthoo, 1999, for an excellent treatment of this approach.) This concept pays, for instance, particular attention to the threat point. This point, to which the countries fall back if negotiations fail, does not play a role in the cooperative solution of Siqueira (2003).

(2005), the electorate as a country's ultimate authority even supports politicians that attach no weight at all to the environment in the case of a global pollutant. As a consequence, even international cooperation does not yield any effective improvement upon the non-cooperative outcome. The implications are less gloomy in the present paper. Since negative grants are excluded, the delegation race to the bottom is bounded from below. Nevertheless, the fundamental tendencies are the same.

A basic difference between Segendorff (1998) and Buchholz et al. (2005) on the one hand and Eckert (2003) and the present paper on the other hand is that in the former contributions there is a continuous delegation choice while in the latter there is only discrete one - either the federal government or the government of the polluting region is entitled to negotiate over an IEA. We show, however, that if the constitutional decision is accompanied by proper grants to fine tune the regional bargaining incentives, the discrete delegation choice is de facto transformed into a continuous choice. In this sense, the current paper bridges the gap between the two strands of literature.

6 Concluding Remarks

In the present paper, we analyze how the prospect of international negotiations over transboundary pollution shapes the countries' constitutional and political decisions. We show that, at the constitutional stage, countries have an incentive to assign the authority over environmental policy and international negotiations to regional governments. Even if this decentralization of power is accompanied by federal grant schemes, the negotiating regions' benefit shares including benefit-related grants fall short of their cost shares. The resulting unfair cost sharing within a country means that the regional negotiators gain less from an IEA than the federal governments. Depressing the bargaining incentives of the domestic negotiators in this way, the federal governments intend to shift the abatement costs to the neighboring country. Since both countries pursue the same strategy, they neutralize each other, at least in the symmetric case. While no side can gain an advantage in the negotiations, the drawback of the non-cooperative constitutional and political decisions becomes apparent. The abatement levels are suboptimally low from the perspective of the countries' as a whole, although an IEA is reached. Both countries are worse off than in the case in which the federal governments enter negotiations.

Our analysis demonstrates that international environmental negotiations by itself are not sufficient to overcome the deficiencies of non-cooperative behavior, since these talks simply shift the problems from the level of the abatement decisions

to the level of the preceding political and constitutional choices. Obviously, the bargaining framework matters, and a truly cooperative solution has to encompass the constitutional and political conditions under which negotiations take place.

Unfortunately, not only decisions on intergovernmental grants and the distribution of power affect the outcome of IEAs.¹⁷ So even if the countries agree on negotiating on the federal level, this does not guarantee a more effective IEA. Rather it might shift the efforts to strategically manipulate the bargaining framework to other areas. Since complete contracts that precisely regulate all the potentially important circumstances are not possible, there always remains a refuge for strategic behavior prior to negotiations. Therefore, it arises the question of whether limiting this strategic behavior partially, even if it is possible, really improves the overall outcome of IEAs. In any case, since the institutional environment in which international negotiations are embedded is of fundamental importance for the resulting agreement, it deserves more attention in future research.

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¹⁷As shown in Copeland (1990), Buchholz and Konrad (1994) and Buchholz and Haslbeck (1997), investment decisions and the choice of environmental technologies can be also used to gain an advantage in ensuing negotiations.

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