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RESEARCH ARTICLE

With or without the European Union: the convention for the protection of the Black Sea against pollution

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Abstract
The Black Sea is an enclosed sea surrounded by six coastal countries, of which Bulgaria and Romania are EU Member States. The Convention for the Protection of the Black Sea Against Pollution was ratified in 1994 by all coastal countries. This Convention is the only European regional sea convention to which the EU is not a Party. While Romania and Bulgaria are in favor of EU accession to the Convention, Turkey, Russia and Ukraine thus far have blocked accession. In this paper, we develop a negotiation model with endogenous enforcement and exogenous fraud to analyze the different positions of groups of coastal countries relative to EU accession to the Convention. Our model contributes to defining a proposal that the EU could make to the opposing states such that they accept the EU as a Party to the Convention. In that context we investigate also whether Romania and Bulgaria might be better off delegating their decision power to the EU, rather than retaining their individual voting rights.

Keywords: Black sea; European Union; Nash-in-Nash; negotiation; pollution

JEL classification: C71; C72; D62; H41; Q53

1. Introduction

The Black Sea is situated in the southeastern part of Europe, surrounded by six coastal states: Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine. Of these, Bulgaria and Romania are European Union (EU) Member States (MSs). At the beginning of the 1990s the Black Sea was described as the "most threatened sea in the world" (Velikova and Oral, 2012: 167). Despite the ratification in 1994 of the Convention on the Protection of the Black Sea Against Pollution, also known as the Bucharest Convention, the Black Sea faces the eutrophication[1] problem caused primarily by nutrient pollutants

[1]See the definition of eutrophication at https://www.eea.europa.eu/help/glossary/other-eea-terms, accessed February 2023.

from agricultural, industrial and urban sectors (Black Sea Commission, 2002; European Environment Agency, 2015). The ineffectiveness thus far of the Bucharest Convention to combat pollution from land-based sources has been due to insufficient commitment by the national governments of the coastal countries, and poor enforcement due to lack of funding, missing priorities for environmental protection, weak institutions and the absence of a compliance instrument in the Convention (Tavitian *et al.*, 2008; European Environment Agency, 2015).

When becoming EU members in 2007, Bulgaria and Romania proposed that the EU becomes a Party to the Convention. However, this was met with opposition by Russia, Turkey and Ukraine. Black Sea Commission documentation[2] shows that Russia's main concern is over the distribution of the voting rights and decision-making rights between the EU Commission and the two MSs, Romania and Bulgaria (Makarenko, 2014). In turn, the Turkish and Ukrainian opposition invoked the current Convention text which does not foresee the possibility of a Regional Economic Integration Organization – like the EU – becoming a Party. Nevertheless, the European Commission considers it a priority for the Bucharest Convention to be amended to allow EU accession (Commission of the European Communities, 2007).

To understand whether the opposition of the non-EU countries is environmentally and economically justified, we analyze theoretically the different positions of *groups of coastal countries* relative to the EU accession. The paper analyzes the incentives of the groups of countries to form cooperative agreements with the EU and how each type of agreement affects these incentives. Thus, apart from the status-quo scenario of the EU not being a Party, we investigate two cooperative scenarios in which the EU is a Party to the Convention, but which differ according to the distribution of authority between the EU and the two MSs. In particular, we investigate whether the MSs coastal countries have an incentive to delegate their decision power to the EU in case the EU is a Party to the Convention.[3] The theoretical and numerical results of the paper contribute to understanding why the EU is not a Party to the Bucharest Convention, despite the proposal made by Bulgaria and Romania. For numerical simulations, our parameter values could not be informed by real data on the Black Sea pollution problem as these data are urgently lacking.[4] We partly address this shortcoming by employing a large set of parameter constellations.

Our paper is related mainly to two strands of literature. The first strand is represented by game-theoretical models of international cooperation to reduce transboundary water pollution, including water pollution between Mexico and the US (Fernandez, 2009), regional pollution in a river basin in China (Shi *et al.*, 2016), nutrient pollution problem in the Baltic Sea (Gren and Folmer, 2003; Ahlvik and Pavlova, 2013) or nutrient pollution problem in the Black Sea (Bayramoglu, 2006). Similarly to the context of our model, Ahlvik and Pavlova (2013) study the problem of cooperation among the Baltic countries to reduce eutrophication, developing a model of coalition formation and dynamic accumulation of nutrients. Their results show that the best institutional arrangement is the

[2] Based on the conclusions of the 3rd meeting of the ad hoc Expert Group on item 8 of the 2009 Ministerial Declaration.

[3] It should be noted that in the event of the EU becoming a Party to the Convention, there would be no increase in voting rights from 6 to 7. Rather, the EU would have 2 voting rights were the MSs to decide to delegate their decision power to the EU, or the MSs would have 1 voting right each were they to decide to retain their decision power.

[4] This data problem for Black Sea pollution is not new. Bayramoglu (2006) also used limited data on only two coastal countries, Romania and Ukraine.

one where the EU uses its enforcement power in the Helsinki Convention to achieve an agreement with full participation and efficient abatement for the MSs, and negotiates with Russia within the agreement. Hence, the authors assume enforcement, whereas we model the enforcement-compliance scheme endogenously in a multi-stage game. To the best of our knowledge, only Bayramoglu (2006) studies the problem of transboundary pollution of the Black Sea in a game-theoretical framework. Focusing on the nitrogen dynamic pollution problem only between Romania and Ukraine, the author shows that the laissez-faire solution, dominates in terms of welfare, the uniform emission policy or the constant emission policy proposed by the Black Sea Commission. In this paper, we consider a different political context in which the EU is a player in the Black Sea pollution mitigation game. In that context, we investigate whether the coastal countries prefer cooperation with the new player EU to the non-cooperative solution.

The second strand of literature regards studies that use compliance models, started by the seminal work of Becker (1968) on the economics of crime. The setting of this article has been used extensively in models of tax evasion (Allingham and Sandmo, 1972; Srinivasan, 1973) and compliance with environmental regulations (Amacher and Malik, 1996; Arguedas, 2005). In particular, Amacher and Malik (1996) and Arguedas (2005) consider enforcement models with negotiations between a regulator and a firm over the reduction of the fines in exchange for environmental cooperation. Our model also includes enforcement, but it considers international negotiations between the EU and the Black Sea coastal countries, in which free-riding incentives exist and leakage is possible.

This paper offers an original theoretical framework that enables the analysis of environmental negotiations between the EU and the coastal states in the presence of costly enforcement. The simultaneous but separate negotiations between the EU and the coastal countries are modeled using Nash-in-Nash bargaining solution. To the best of our knowledge, ours is the first paper to apply Nash-in-Nash bargaining solution to a transboundary pollution problem. Our theoretical model that combines endogenous enforcement, international environmental negotiations, and the option to delegate decisions allows us to investigate potential institutional solutions to the Black Sea pollution problem in the absence of a compliance mechanism in the Bucharest Convention.

The paper is organized as follows. Section 2 introduces the model. We present the analytical results in section 3. Using quadratic functions and numerical examples, section 4 presents results regarding scenario choice and comparative statics. Section 5 concludes.

2. Model

We consider the six Black Sea coastal countries and the large player, the EU. The coastal countries can be divided into two groups according to their EU membership. The EU-membership status matches quite well the position relative to the accession of the large player as a Party to the Convention. Romania and Bulgaria are EU MSs and have proposed the accession of the EU to the Bucharest Convention. Therefore, we consider Bulgaria and Romania as a single player denoted by i.

The other four countries, Georgia, Russia, Turkey and Ukraine, are not EU MSs and Russia, Turkey and Ukraine are rather antagonistic towards the EU accession. Hence, we treat this second group of countries as a single player denoted by j. The caveat is that Georgia is somewhat in between the two groups of countries, i and j: although not a EU MS, Georgia has expressed its support for the EU accession to the Convention. Yet, we believe that the split of the six coastal countries according to the EU-membership best reflects the institutional assumptions of the model, as will become clear shortly. It could also be argued that, due to the recent political and military conflicts, Russia and Ukraine should be treated separately. While this might be appropriate if we were to consider bilateral relations between the two nations, we believe that it matters less for the context of the Bucharest Convention. Thus, we include these two countries in the same block, as their attitudes towards the EU accession are similar and they are both non-EU MSs. Considering each country as a separate player would make the analysis intractable in the framework of our four-stage game with multiple negotiations.

We assume the following payoff functions for player $k = i, j$:

$$U_k(a_k, A, \bar{a}_k, t_k, p) = \alpha_k B(A) - C(a_k) + (1 - \lambda_k)t_k - pF(\bar{a}_k - a_k), \tag{1}$$

where $B(\cdot)$ is the benefit function of the total abatement efforts $A = a_i + a_j$ to reduce pollution which we assume, for simplicity, to be of uniformly-mixed nature. As usual, we assume that B is increasing and concave: $B'(A) > 0$ and $B''(A) \leq 0$. This means that the marginal benefit of abatement is (weakly) decreasing. Rather than measuring heterogeneous damage to the countries from total pollution, parameters $\alpha_j < \alpha_i \leq 1$ capture here the heterogeneity in *preferences* for the public good between the two groups of countries, in the same vein as in Petrakis and Xepapadeas (1996). Hence, the group opposing the EU accession is assumed to care less about total abatement, and implicitly about pollution, than the group of countries favoring the EU accession, assumed to be more committed to cooperation with the EU. The higher environmental concern of the EU coastal countries is also justified by their commitments under the EU Marine Strategy Framework Directive (MSFD)[5] which includes measures for enforcement (Ahlvik and Pavlova, 2013).

The second term in equation (1) is the abatement cost function $C(\cdot)$, which is assumed increasing and convex, $C'(\cdot) > 0$ and $C''(\cdot) > 0$, and to be the same for the two groups of countries. This means that the marginal abatement cost is increasing. The third term, t_k, is the transfer received by players k from the large player, the EU. In reality, the European Commission provides several funding opportunities for Black Sea-related projects in all coastal countries. One example is the MISIS project whose beneficiaries are Bulgaria, Romania and Turkey (European Commission, 2021a). Another example is the EMBLAS project whose beneficiaries are Georgia, Russian Federation and Ukraine (EMBLAS Project, 2021).

Parameters $0 \leq \lambda_k < 1$, $k = i, j$ are a measure of fraud or misuse of funds transferred from the large player to the two groups of countries, and they can differ between the two groups. Thus, the larger the λ_k, the higher the level of fraud in country-group k, i.e. the proportion of the transfer funds that is diverted from their pre-established destination of improving the environmental quality of the sea. The misuse of funds defined by parameter λ_k in our model may be related to the poor quality of institutions and corruption in the Black Sea coastal countries.[6]

[5]The coastal countries Bulgaria and Romania are also bound to adhere to other EU regulations for the protection of the sea, such as the Water Framework Directive and the EU Common Fishery Policy, while the non-EU coastal states have no obligation to comply (Freire-Gibb *et al.*, 2014).

[6]According to Transparency International, the Parties to the Convention have Corruption Perception Indices for 2020 of between 30 and 56, with 0 indicating high corruption and 100 indicating no corruption. The average for the six coastal countries is 41, indicating endemic corruption.

In sum, there are two sources of heterogeneity between players i and j: the benefit from total abatement and the degree of misuse of transfer receipts. In order to disentangle the effects of the two sources of heterogeneity and to keep the analysis tractable, we assume that players are similar with respect to abatement cost technology. Even though the abatement costs are likely to be different, we believe that the two groups of countries differ more with respect to the taste for the environment and the degree of misuse of transfer funds than they differ with respect to the abatement costs. The preference for the environmental quality might be different between the EU MSs and non-MSs due to differences in income and environmental policy stringency. Similarly, we expect the degree of misuse of transfer funds to be heterogeneous between the EU MSs and non-MSs due to differences in institutional quality and more enforcement in the EU.

The last term in equation (1) is a penalty function for under-compliance relative to a negotiated level of abatement $\bar{a}_k$, $k = i, j$, such that $F(\bar{a}_k - a_k) > 0$ for $\bar{a}_k - a_k > 0$ and $F(\bar{a}_k - a_k) = 0$ for $\bar{a}_k - a_k \leq 0$. Using $m_k = \bar{a}_k - a_k > 0$ to denote the level of under-compliance, we assume that the penalty function is linear in the level of under-compliance: $F'(m_k) > 0$ and $F''(m_k) = 0$.[7] Although the linearity assumption might appear restrictive, linear fines have the practical advantage of being easy to understand. For instance, linear penalty functions are used in national laws to comply with the international rules and standards in the domain of maritime oil-pollution. Denmark applies a linear penalty of about 33 euro for each liter of oil spilled in excess of 1,000 L (OSPAR Commission, 2010).

Finally, $p \in [0, 1]$ is the inspection probability. We assume that if the inspection occurs, the EU can perfectly observe the level of abatement undertaken by countries. The inspection can, for example, be conducted by measuring the nutrient load in the water, which is nevertheless costly for the EU to conduct.[8] It is therefore worth noting from equation (1) that a penalty occurs only if the inspection occurs (see the term $pF(\bar{a}_k - a_k)$). Hence, we model here a game of complete information as opposed to one of asymmetric information in which the level of abatement would only be inferred from signals.

Since players have different preferences for environmental quality and they likely face different negotiated abatement standards, their marginal benefits from violating the standards will be different. This likely calls for different monitoring levels on the part of the EU. However, we assume here that inspection probabilities are the same for the inspected players i and j. Our objective is to analyze how the random inspection modifies the negotiation variables and the abatement compliance by individual players, and not to analyze how the heterogeneity in inspection affects these outcomes.

The payoff function of the large player, the EU, is defined as

$$U(a_i, a_j, A, \bar{a}_i, \bar{a}_j, t_i, t_j, p) = B(A) - t_i - t_j + p\left[F(\bar{a}_i - a_i) + F(\bar{a}_j - a_j)\right] - I_T(n, p), \quad n \in \{1, 2\}, \tag{2}$$

[7] We have alternatively considered a quadratic penalty function. This case greatly complicates the calculations so that at the first stage of the game, there is no real solution but an imaginary solution for the inspection probability (p). Thus, none of the cooperative scenarios can be solved numerically in this case. The reason is that at the second stage of the game, the negotiated standards and transfers are now higher degree polynomial functions of inspection probability (p), with powers 6 and 14 respectively.

[8] The inspection cost is discussed below.

where function $I_T(n, p) = n \times I(p)$ represents the total inspection cost, with $I(0) = 0$, $I'(p) > 0$, $I''(p) \geq 0$ and $n \in \{1, 2\}$ being the number of players inspected, depending on the institutional arrangement.[9] Apart from benefiting from total abatement, the large player also derives payoff from the penalty charged to both players for their non-compliance with the negotiated abatement levels. It also incurs costs for the transfers paid to the coastal countries, and for inspections.

Hence, in our model, in case of under-compliance with agreed abatement standards, the coastal countries, including the non-MSs, pay penalties to the EU. This is determined through inspection. For example, the results of the projects mentioned above are not only monitored via periodic reporting, but they are also audited by third parties on behalf of the sponsor.[10] Hence, there is monitoring and verification of fulfilling the objectives of the projects for which funds have been received and both explicit and implicit penalties may apply. For non-MSs, the EU may apply implicit rather than explicit penalties. Implicit penalties can take the form of forfeit of future funding for environmental projects such as the already mentioned MISIS and EMBLAS, or provision of less development aid for non-environmental projects in some coastal countries (e.g., Turkey and Georgia which currently are recipients of EU development aid).

In this model, the EU as a Regional Economic Integration Organization is considered to be an independent actor with its own preferences. In particular, it is assumed to be at least as sensitive to total pollution as the MS coastal countries, while the MS coastal countries are assumed to be more sensitive to total pollution than the non-MS coastal countries ($\alpha_j < \alpha_i \leq 1$).[11] This assumption can be justified in different ways. First, there is the clearly expressed intention of the EU to be part of the Bucharest Convention. Second, the EU represents the environmental preferences of a large number of citizens with a certain willingness to pay for environmental services from the Black Sea (swimming, waters sports, recreational fishing, consumption of marine fish, and other ecosystem services). Third, demand for environmental protection from a larger and richer population conditions the stringency of EU environmental policies.

It is important to stress that we do not model EU decision-making based on a social welfare function, which would be a sum of the payoffs for all the EU countries. Recall that the EU's preferences for total abatement are given by $\alpha B(A)$ with $\alpha = 1$. We posit that this unitary value is the result of a (previous) EU level vote, which represents the collective value of all EU countries of Black Sea pollution mitigation. This vote includes all EU MSs including the coastal MSs, Romania and Bulgaria. Some MSs have a higher valuation ($\alpha_i > 1$), others a lower valuation ($\alpha_i < 1$). The result of the vote converges to $\alpha = 1$. This does not prevent individual countries from having their own valuations as sovereign states. In our case, we posit that the two coastal MSs have a lower valuation of $\alpha_i \leq 1$, and take account of this when negotiating with the EU in becoming a Party to the Bucharest Convention.

[9] Here, we assume that inspection costs are identical for inspecting each group of countries. In section 5, we relax this assumption and study the implications of heterogeneous monitoring costs.

[10] As for now, since there are no abatement targets for the Black Sea, we cannot mention cases of inspection against negotiated targets. However, what comes closest to the context of our model is the annual verification of the EU ETS installations, in addition to the monitoring reports submitted by the regulated entities (European Commission, 2021b).

[11] Note that we do not model EU decision-making as a federation problem. We model the case of the Bucharest Convention in which the EU expressed its intention to participate as a separate Party from the two coastal MSs.

3. Scenarios

We investigate three scenarios which differ with respect to the position in the Convention of the large player, the EU. The first scenario is the *status-quo* scenario in which the EU is not a Party to the Convention, and thus has no enforcement power over the abatement efforts of the two groups of countries, i.e., $p = 0$. Moreover, although in reality the EU makes transfers to the coastal countries even in the status-quo scenario, we assume that if this happens, the payment is for other purposes and thus is outside the decision framework of our model. Therefore, $t_i = t_j = 0$. We model the status quo as a non-cooperative situation described by a Nash equilibrium. The reason is that coastal countries have not undertaken sufficient abatement efforts to internalize pollution externalities, even though they have been parties to the Bucharest Convention since 1994. In the absence of a complete dataset on the evolution of the nutrient pollution stock in the Black Sea, the state of fishery resources can be used to highlight the poor environmental state of the Black Sea. Land-based pollution loads, especially agricultural emissions, are responsible for the depletion of fish stocks, in addition to the over-exploitation of fishery resources (Bayramoglu, 2006). FAO (2018) reports that in the Black Sea, piked dogfish and turbot are considered to be depleted, with moderate signs of improvement for the latter. Furthermore, according to the estimates for the period from 1960–2009 presented in a report of the Commission on the Protection of the Black Sea Against Pollution, there is a clear increase in the mortality of turbot in the period after the Convention was signed (Black Sea Commission, 2019).

In both of the other two scenarios, the EU is a Party to the Bucharest Convention so that via a control-and-verification mechanism it can negotiate and enforce certain abatement levels on the coastal countries. Thus, the second scenario, which we call the *no-block* (or *no-delegation*) scenario is that in which the large player is a Party to the Convention, but the MSs decide their individual abatement levels independently. In this case, we say that the EU does not form a decision block with the MSs or the MSs do not delegate their abatement decisions to the EU. As a Party to the Convention, the EU can make transfers to all coastal countries to compensate them for undertaking some negotiated abatement effort. For this reason, we assume that the large player has monitoring and verification power. The timing of this game is as follows:

- Stage 1: The large player decides on the frequency of controlling the actual abatement level against a negotiated level: the inspection probability p.
- Stage 2: The large player negotiates separately with each of the two players on the levels of abatement and transfers: $\bar{a}_i$, $\bar{a}_j$, t_i and t_j.
- Stage 3: Each player decides on its abatement compliance level: a_i and a_j.
- Stage 4: Inspection takes place and fines are applied in case of under-compliance.

The third scenario is the *block (or delegation)* scenario. This scenario is almost identical to the *no-block* scenario except that instead of player i deciding its own level of abatement, it delegates this decision to the large player so that they form a decision block. In this case, the EU internalizes the benefits and costs of player i and decides the abatement level a_i. Thus, in stage 2 only $\bar{a}_j$ and t_j are negotiated.

For each of the three scenarios described above the game is solved by backward induction. The status-quo scenario, which is the non-cooperative case, serves as the threat point for the negotiations that occur in the other two scenarios. We start by presenting the full cooperative solution as the benchmark case.

3.1. Full cooperative solution

We characterize the full cooperative solution because it represents a theoretical reference with respect to the ideal situation. In this case, the social planner maximizes the sum of all the players' payoffs and selects the abatement standard levels for all players, with which all players perfectly comply, as if the inspection probability was 1 or the inspection cost was null. Consequently, there is no need to implement a transfer scheme to incentivize compliance with the abatement standards and the misuse of funds does not play a role.

The objective of the social planner is

$$\max_{a_i,a_j} W = (1+\alpha_i+\alpha_j)B(A) - C(a_i) - C(a_j). \tag{3}$$

The first-order conditions (FOCs) with respect to each of the abatement levels yield the following system of equations:

$$B'(A) = \frac{C'(a_i)}{1+\alpha_i+\alpha_j} = \frac{C'(a_j)}{1+\alpha_i+\alpha_j}. \tag{4}$$

Given that the marginal abatement cost function is strictly increasing, equation (4) implies that $a_i^{FC} = a_j^{FC} = a^{FC}$, where FC denotes *full cooperation*. Hence, there is a unique solution,[12] a^{FC}, to the optimization program (3), such that

$$B'(2a^{FC}) = \frac{C'(a^{FC})}{1+\alpha_i+\alpha_j}. \tag{5}$$

The resulting social welfare function is given by: $W = (1+\alpha_i+\alpha_j)B(2a^{FC}) - 2C(a^{FC})$.

3.2. Status-quo scenario

We assume that when the players do not cooperate, they choose Nash equilibrium strategies. In this case, the payoff functions of player $k = i, j$ and the large player are given respectively by:

$$U_k(a_k, A) = \alpha_k B(A) - C(a_k) \tag{6}$$

$$U(A) = B(A). \tag{7}$$

The objective of each player is to maximize its own payoff taking the abatement level of the other player as given. The FOCs give[13]

$$B'(A) = \frac{C'(a_i)}{\alpha_i} = \frac{C'(a_j)}{\alpha_j}. \tag{8}$$

[12]Note that The Hessian matrix of the second derivatives of the social welfare function is given by

$$H^{FC} = \begin{pmatrix} (1+\alpha_i+\alpha_j)B''(A) - C''(a) & (1+\alpha_i+\alpha_j)B''(A) \\ (1+\alpha_i+\alpha_j)B''(A) & (1+\alpha_i+\alpha_j)B''(A) - C''(a) \end{pmatrix}.$$

The first determinant of H^{FC}, $D_1 = (1+\alpha_i+\alpha_j)B''(A) - C''(a) < 0$ and $D_2 = Det(H^{FC}) = (C''(a))^2(1 - (1+\alpha_i+\alpha_j)B''(A)) > 0$, by the model assumptions. Thus H^{FC} is negative definite.

[13]The associated second-order condition is $\alpha_i B''(A) - C''(a_i) < 0$ for i.

We denote the solution to this system of equations by a_i^{SQ} and a_j^{SQ}, where SQ denotes *status quo*. Since $\alpha_j < \alpha_i$, it is clear from (8) that $a_i^{SQ} > a_j^{SQ}$.

The following lemma can be established by comparing these abatement levels with those of the full cooperation solution.

Lemma 1 : *For each of the two players, the individual abatement levels are higher in the full-cooperation solution than in the status quo. Consequently, the total abatement is higher in the full-cooperative solution than in the status quo, i.e.,* $A^{FC} > A^{SQ}$.

Proof : Comparing (4) to (8), it follows that the individual abatement levels of both players are lower in the status quo than in the full-cooperation scenario. □

We denote the resulting status-quo payoff levels, obtained by plugging the equilibrium levels from (8) into (6) and (7), by U_i^{SQ}, U_j^{SQ} and U^{SQ}, for the two players and the large player, respectively.

3.3 The no-block scenario

In this scenario, in the third stage the two players choose their abatement levels non-cooperatively, taking into account the inspection probability p decided in stage 1 and the negotiated abatement level $\bar{a}_i$ and $\bar{a}_j$ decided in stage 2. Thus, the problem solved by player $k = i, j$ in the third stage is

$$\max_{a_k} U_k = \alpha_k B(a_i + a_j) - C(a_k) + (1 - \lambda_k)t_k - pF(\bar{a}_k - a_k), \tag{9}$$

and the FOC with respect to a_k reads[14]

$$B'(A) = \frac{C'(a_k) - pF'(\bar{a}_k - a_k)}{\alpha_k}, \; k = i, j. \tag{10}$$

In online appendix A2.2, we show that the abatement compliance levels are substitutes, i.e., there is leakage in the no-block scenario: $da_i^{NB}/da_j^{NB} \leq 0$. Note that for a linear penalty function which is assumed throughout the paper, $F'' = 0$, the actual abatement is independent of the negotiated abatement level, i.e., $da_i^{NB}/d\bar{a}_i = da_j^{NB}/d\bar{a}_j = da_j^{NB}/d\bar{a}_i = da_i^{NB}/d\bar{a}_j = 0$. Solving the system of equations (10), we obtain $a_i^{NB} = a_i^{NB}(\bar{a}_i, \bar{a}_j, p)$ and $a_j^{NB} = a_j^{NB}(\bar{a}_i, \bar{a}_j, p)$, where NB denotes *no-block*.[15] Hence, the following lemma can be established.

Lemma 2 : *The random inspection induces a higher level of abatement compared to the status quo, i.e.,* $a_k^{NB} > a_k^{SQ}$ *for* $k = i, j$.

[14]The second-order condition is verified because $\alpha_k B''(A) - C''(a_k) < 0$, $k = i, j$.

[15]Note that for the moment we do not assume explicit functional forms. Therefore, we cannot solve explicitly for the equilibrium values of the variables of interest. In section 4, we assume quadratic functional forms and the equilibrium values for this version of the model are presented in online appendix B.

Proof : Comparing (8) to (10) for $k = i, j$, and accounting for the monotonicity of the functions involved, it follows that the inspection probability induces a higher level of abatement, i.e., $a_i^{NB} > a_i^{SQ}$ and $a_j^{NB} > a_j^{SQ}$. □

The random inspection by the large player and the occurrence of fines for under-compliance provide the right incentives to players to increase their abatement compliance level compared to the status quo.

In the second stage of the game, the large player negotiates simultaneously and separately with each of the two players, to determine the abatement targets $\bar{a}_i$ and $\bar{a}_j$, and the compensatory transfers t_i and t_j anticipating the compliance levels from the third stage and accounting for the inspection probability from the first stage. The outcome of the negotiations is determined through a Nash bargaining solution (Nash, 1950), where the surplus is split via transfers according to parties' bargaining powers, and where the threat point is given by the status quo. Thus, in the case of the negotiations between player i and the EU, the parties maximize the Nash product[16]

$$\max_{t_i,\bar{a}_i}[U_i - U_i^{SQ}]^{\gamma_i} \times [U - U^{SQ}]^{1-\gamma_i},$$

where γ_i is the relative bargaining power of player i in relation to the bargaining power of the large player.[17] Recall that we have $U_i = \alpha_i B(\bar{A}) - C(\bar{a}_i) + (1 - \lambda_i)t_i - pF(\bar{a}_i - a_i^{NB})$ and $U = B(\bar{A}) - t_i - t_j + p[F(\bar{a}_i - a_i^{NB}) + F(\bar{a}_j - a_j^{NB})]$.

In the no-delegation equilibrium, we consider a special setting with simultaneous but separate negotiations between the EU and player i on the one hand, and the EU and player j on the other. In this setup, the EU is the common player in both negotiations, but players i and j do not negotiate directly.

The Nash-in-Nash solution concept proposed by Horn and Wolinsky (1988) applies to this simultaneous separate bargaining situation. This solution concept is used extensively in the industrial organization literature to model bilateral negotiations between manufacturers and retailers in a vertical relationship (Collard-Wexler *et al.*, 2019). Bagwell *et al.* (2020) were the first to employ the equilibrium solution concept to model simultaneous bilateral tariff negotiations in a three-country model of international trade.

In the Horn and Wolinsky (1988) solution, "*. . . the price negotiated between any pair of firms is the Nash bargaining solution (Nash 1950) for that pair given that all other pairs reach agreement*" (Collard-Wexler *et al.*, 2019: 165). In our model, player i negotiates with the EU, taking as given the negotiated abatement of player j in the other negotiation with the EU. This condition holds also for the negotiation between the EU and player j. The negotiated abatement ($\bar{a}_i$) affects the total negotiated abatement ($\bar{A}$) which, in turn, affects the payoffs (and negotiation outcome) associated with negotiated abatement ($\bar{a}_j$) in the other bilateral negotiation. Thus, bilateral negotiations are mutually dependent.

The Nash bargaining solution for the negotiation between the EU and player i leads to the FOCs for the negotiated abatement and transfer levels, $\bar{a}_i = \bar{a}_i(\bar{a}_j, \bar{A}, t_i, t_j, p)$ and $t_i = t_i(t_j, \bar{a}_i, \bar{a}_j, \bar{A}, p)$. In a similar way, the Nash bargaining solution for the negotiation between the EU and player j leads to the following FOCs, $\bar{a}_j = \bar{a}_j(\bar{a}_i, \bar{A}, t_i, t_j, p)$ and

[16]The FOCs for maximizing the Nash product are derived in online appendix A1.

[17]The analogous Nash product for the negotiation between player j and the EU is $\max_{t_j,\bar{a}_j}[U_j - U_j^{SQ}]^{\gamma_j} \times [U - U^{SQ}]^{1-\gamma_j}$.

$t_j = t_j(t_i, \bar{a}_i, \bar{a}_j, \bar{A}, p)$. The FOCs on transfers imply respectively for players i and j :

$$\frac{U - U^{SQ}}{U_k - U_k^{SQ}} = \frac{1 - \gamma_k}{\gamma_k(1 - \lambda_k)}, \quad k = i, j. \tag{11}$$

When we substitute conditions (11) in the FOCs on negotiated abatement, for the case of a linear penalty function ($F'' = 0$), we obtain

$$B'(\bar{a}_i + \bar{a}_j) = \frac{C'(\bar{a}_k) + p\lambda_k F'\left(\bar{a}_k - a_k^{NB}\right)}{\alpha_k + (1 - \lambda_k)}, \quad k = i, j. \tag{12}$$

In the online appendix (A2.2), we show that the negotiated levels of abatement are always substitutes, i.e., there is leakage in negotiated abatement in the no-block scenario: $d\bar{a}_i^{NB}/d\bar{a}_j^{NB} \leq 0$.

Solving the system of equations (12), we obtain the negotiated levels of abatement under the no-block scenario as functions of the inspection probability decided in stage 1 of the game: $\bar{a}_i^{NB} = \bar{a}_i^{NB}(p)$ and $\bar{a}_j^{NB} = \bar{a}_j^{NB}(p)$. Similarly, solving the system of equations (11), we obtain the negotiated levels of transfers under the no-block scenario as functions of the inspection probability: $t_i^{NB} = t_i^{NB}(p)$ and $t_j^{NB} = t_j^{NB}(p)$.[18] Equations (A1.5) and (A1.6) in online appendix A1 show that in the no-block scenario, the transfer levels of both players depend on the respective negotiation power of the players γ_i and γ_i, in relation to the EU, and on all the parameters describing the payoff functions of the three players, i and j, and the EU. Section 4.2 discusses the effect of misuse of funds on the negotiated transfers based on numerical simulations. Other comparative statics on transfer levels in the no-block case, and the numerical results, are provided in section 4. The following proposition can be established.

Proposition 1 (Negotiated abatement and the level of fraud): *The negotiated abatement level $\bar{a}_k^{NB}$, $k = i, j$, is a decreasing function of the loss in transfer receipts λ_k. The relationship for player i is defined by:*

$$\frac{d\bar{a}_i^{NB}}{d\lambda_i} = \frac{B'(\bar{a}_i^{NB} + \bar{a}_j^{NB}) + pF'(\bar{a}_i^{NB} - a_i^{NB})}{B''(\bar{a}_i^{NB} + \bar{a}_j^{NB})\,(\alpha_i + (1 - \lambda_i))\left(\frac{C''(\bar{a}_j^{NB})}{C''(\bar{a}_j^{NB}) - B''(\bar{a}_i^{NB} + \bar{a}_j^{NB})(\alpha_j + (1 - \lambda_j))}\right) - C''(\bar{a}_i^{NB})} < 0.$$

The symmetric relationship holds for player j.

Proof : See the online appendix, section A3. □

Proposition 1 shows that the higher the level of fraud in transfers, the lower the negotiated abatement level. The intuition is the following. The higher the level of fraud in transfers, the smaller the cake to be shared among the negotiating partners, which results in fewer funding possibilities. The recipient country is thus less willing to agree

[18]The expressions of the negotiated transfers are provided in section A1 of the online appendix.

to an ambitious abatement target. Proposition 2 compares the actual and negotiated abatement levels between players *i* and *j*.

Proposition 2 (Comparison of actual and negotiated abatement levels): *Assuming the same degree of misuse of transfer receipts by players i and j,* $\lambda_i = \lambda_j = \lambda$,

1. *the abatement compliance level of player i is larger than that of player j:* $a_i^{NB} > a_j^{NB}$,
2. *the negotiated abatement level for player i is larger than that of player j:* $\bar{a}_i^{NB} > \bar{a}_j^{NB}$.

Proof : See online appendix, section A4. □

Proposition 2 results in two interesting findings. For a given inspection probability and for a similar degree of misuse of transfer receipts, player *i*, who cares more about the environment, negotiates a more ambitious abatement level and also undertakes a higher level of abatement than player *j*. Since abatement compliance and negotiated abatement levels are strategic substitutes between the two country groups, this means that player *j* free-rides in both the negotiation and compliance stages. Proposition 3 gives the relationship between the policy instruments of the EU.

Proposition 3 (Substitute vs. complementary policy variables): *The relationship between the negotiated level of abatement and the inspection probability is defined by*

$$\frac{d\bar{a}_i^{NB}}{dp} = \frac{-\lambda_i F'(\bar{a}_i^{NB} - a_i^{NB})D_j + \lambda_j F'(\bar{a}_j^{NB} - a_j^{NB})B''(\bar{a}_i^{NB} + \bar{a}_j^{NB})\,(\alpha_i + (1-\lambda_i))}{C''(\bar{a}_j^{NB})\,(\alpha_i + (1-\lambda_i))\,B''(\bar{a}_i^{NB} + \bar{a}_j^{NB}) + C''(\bar{a}_i^{NB})D_j}$$

where $D_j = B''(\bar{a}_i^{NB} + \bar{a}_j^{NB})(\alpha_j + (1-\lambda_j)) - C''(\bar{a}_j^{NB}) < 0$.

1. *In the presence of fraud in transfers, i.e.,* $\lambda_i, \lambda_j > 0$, *the sign of the slope is ambiguous.*
2. *If fraud in transfers is missing in at least one of the two groups of countries, then the sign of the slope is as follows: (i) if* $\lambda_i = 0$ *and* $\lambda_j > 0$, *then* $d\bar{a}_i^{NB}/dp > 0$; *(ii) if* $\lambda_i > 0$ *and* $\lambda_j = 0$, *then* $d\bar{a}_i^{NB}/dp < 0$.
3. *If fraud in transfers is missing in both groups of countries, i.e.,* $\lambda_i = \lambda_j = 0$, *then the negotiated abatement level is independent of the probability of inspection.*

Proof : See the online appendix, section A5. □

Proposition 3 indicates that the existence of fraud in monetary transfers in at least one of the two groups of countries induces an effect of the inspection probability on the negotiation outcome (cases (1) and (2)). In the case of unilateral fraud by player *j* (case (2i)), the absence of losses in transfers for player *i* implies a higher negotiated abatement level for that player (Proposition 1). In this case, the EU has incentives to increase its inspection probability in order to obtain high penalty receipts from this player for under-compliance. Hence, a high individual negotiated standard coexists with a high inspection probability, which means that the inspection frequency and the negotiated standard are strategic complements from the large player's point of view, despite inspection being costly for that player. The reverse holds if fraud takes place only in the country group i. However, in the absence of fraud by both players, the negotiated abatement level is independent of the probability of inspection (case (3)). If both players engage in fraud, the sign of the slope is ambiguous, depending on the relative level of fraud (case (1)).

Finally, in the first stage of the game, the large player decides on the inspection probability p. To do this, the large player maximizes (2) with respect to p, anticipating the negotiated and compliance levels of abatement. Note that for a risk-neutral decision-maker as it is assumed for the EU in this model, choosing the inspection probability p is equivalent to choosing the penalty function F because the two decision variables are substitutes. Since an optimal combination of p and F does not exist (Phaneuf and Requate, 2017: 199), we assume the structure of the penalty function F to be exogenously given and take p as the decision variable. The FOC of (2) with respect to p, anticipating a_k^{NB}, $\bar{a}_k^{NB}$, t_k^{NB}, $k = i, j$, is

$$\left(\frac{da_i^{NB}}{dp} + \frac{da_j^{NB}}{dp}\right) B^{'}(a_i^{NB} + a_j^{NB}) - \frac{dt_i^{NB}}{dp} - \frac{dt_j^{NB}}{dp} + F(\bar{a}_i^{NB} - a_i^{NB}) + F(\bar{a}_j^{NB} - a_j^{NB})$$
$$+ p\left[\left(\frac{d\bar{a}_i^{NB}}{dp} - \frac{da_i^{NB}}{dp}\right) F'(\bar{a}_i^{NB} - a_i^{NB}) + \left(\frac{d\bar{a}_j^{NB}}{dp} - \frac{da_j^{NB}}{dp}\right) F'(\bar{a}_j^{NB} - a_j^{NB})\right] = 2\frac{dI}{dp}, \tag{13}$$

which implicitly defines the probability of inspection in the *no block* case p^{NB}. A closed-form solution for p cannot be derived from equation (13) since every term in this equation depends on p.[19] However, an interpretation of equation (13) reads that the total marginal cost of inspection to the EU is equal to the expected marginal benefit from enforcement. The latter includes the expected marginal benefit from better environmental quality and the receipt of penalty payments for under-compliance, net of marginal transfer payments.

3.4 The block scenario

It is not obvious what the objective of the large player should be when acting on behalf of player i, but a natural assumption is that the large player maximizes the joint payoff between itself and player i. We do not model the decision about the split of this payoff between player i and the large player.[20] To distinguish this payoff from the payoff of the large player alone, as modeled in the *no-block* scenario, we use the subscript L. Thus, the payoff of the large player reads

$$U_L = (1 + \alpha_i)B(a_i + a_j) - C(a_i) - t_j + pF(\bar{a}_j - a_j) - I(p). \tag{14}$$

In this scenario, we assume that the large player internalizes the costs and benefits of player i. Thus, the level of abatement for i is decided by the large player and, also, is enforced by the large player at zero cost, such that there is no negotiation between

[19] Note that no closed-form solution for p can be found for the example with quadratic functions in section 4. We can only solve for p numerically.

[20] In the numerical simulations below, we assume an exogenous split $0 \leq \delta \leq 1$ of the joint payoff. In section 3.5, we note that the existence of the delegation equilibrium will, nonetheless, impose an interval on the values of the split parameter δ.

the large player and player *i*, i.e., $a_i = \bar{a}_i$.[21] Hence, there is no need for the large player to make a monetary transfer to player *i* as compensation for its abatement effort, i.e., $t_i = 0$. Note, however, that the payoff function of the large player still includes the monetary transfers to player *j*, the potential fine for non-compliance with this player's negotiated abatement level and the cost of monitoring player *j*'s compliance.

With the exception of Proposition 2, which cannot be reproduced analytically, we also provide the theoretical results for the block scenario. It is possible only to reproduce Lemma 2 analytically for the comparison between total abatement levels, but not in terms of the individual abatement levels. In order to avoid repetition, these results are provided in the online appendix, section A7.

In the third stage, the large player determines the abatement level of player *i* maximizing the payoff of the block:

$$\max_{a_i} U_L = (1 + \alpha_i)B(a_i + a_j) - C(a_i) - t_j + pF(\bar{a}_j - a_j) - I(p). \tag{15}$$

Note that, in this case, the EU inspects only player *j*, and therefore pays only $I(p)$ in inspection cost, instead of $2 \times I(p)$ in the no-block scenario. The FOC of (15) with respect to a_i is[22]

$$B'(A) = \frac{C'(a_i)}{1 + \alpha_i}. \tag{16}$$

Comparing a_i resulting from equation (16) to the compliance level chosen by player *i* in status quo (equation (8)), it is clear that delegating the decision to the large player results in higher abatement levels because the benefit of the larger player is internalized. On the other hand, compared to the compliance decision when player *i* is still under the scrutiny of the large player (equation (10)), it is not always clear that forming a block with the large player induces player *i* to abate more.

In this stage, player *j* continues to decide her level of abatement unilaterally, and this continues to be given by the analogous form of condition (10) for $k = j$,

$$B'(A) = \frac{C'(a_j) - pF'(\bar{a}_j - a_j)}{\alpha_j}. \tag{17}$$

In the online appendix, section A7.1, as in the no-block scenario, we show that the abatement compliance levels are substitutes in the block scenario: $da_i^B / da_j^B \leq 0$.

Due to the linearity of the penalty function, we have $da_i^B / d\bar{a}_j = 0$ and $da_j^B / d\bar{a}_j = 0$. Hence, the equilibrium abatement levels in the third stage of the game with the EU block are given by the system of equations consisting of equations (16) and (17), resulting in $a_i^B = a_i^B(p)$ and $a_j^B = a_j^B(p)$.[23]

In the second stage, player *j* negotiates with a "larger" player than in the *no-block* case, because now the EU decides jointly with player *i*, having the joint payoff function given

[21] The level of abatement a_i by player *i* could also be enforced for a cost by the large player. Nonetheless, the payoff of the large player would be the same because the payment and receipt of fines and monetary transfers would cancel out within the block.

[22] The second-order condition is verified: $(1 + \alpha_i)B''(A) - C''(a_i) < 0$.

[23] The second-order condition is verified: $\alpha_j B''(A) - C''(a_j) - pF''(\bar{a}_j - a_j) < 0$.

by equation (15). The Nash bargaining problem now reads[24]

$$\max_{t_j,\bar{a}_j}[U_j - U_j^{SQ}]^{\gamma_j}[U_L - U^{SQ}]^{1-\gamma_j}. \tag{18}$$

Recall that we have $U_L = (1+\alpha_i)B(a_i^B + \bar{a}_j) - C(a_i^B) - t_j + pF(\bar{a}_j - a_j^B) - I(p)$ and $U_j = \alpha_j B(a_i^B + \bar{a}_j) - C(\bar{a}_j) + (1-\lambda_j)t_j - pF(\bar{a}_j - a_j^B)$. The FOCs for the optimization of (18) are given in the online appendix, section A6, providing the expression of the negotiated abatement level for player j as a function of the inspection probability: $\bar{a}_j^B = \bar{a}_j^B(p)$. Using the linearity of the penalty function, we obtain the following FOC for country j:

$$B'(a_i^B(p) + \bar{a}_j) = \frac{C'(\bar{a}_j) + p\lambda_j F'\left(\bar{a}_j - a_j^B(p)\right)}{\alpha_j + (1-\lambda_j)(1+\alpha_i)}. \tag{19}$$

Finally, the transfer to player j is given by

$$t_j^B(p) = \gamma_j(u_L^B(p) - U^{SQ}) - \frac{1-\gamma_j}{1-\lambda_j}\left(u_j^B(p) - U_j^{SQ}\right), \tag{20}$$

where u_j^B and u_L^B are defined similarly to the no block case, except that for u_L^B there is no longer a penalty receipt from, and no transfer payment to, player i.

Note that, based on equation (20), nothing can be said about the behavior of the transfer payment with respect to the negotiation power γ_j or the fraud λ_j parameters. This is because it is not possible analytically to determine the relationship between the payoffs in the block scenario and the status-quo scenario. It can be determined only based on the numerical simulations which allow for a discussion (in section 4.2) of the effect of fraud on the transfers.

In the first stage of the game, to decide the inspection frequency of player j, the large player maximizes

$$\begin{aligned}\max_p U_L(a_i^B, a_j^B) &= (1+\alpha_i)B(a_i^B(p) + a_j^B(p)) \\ &\quad - C(a_i^B(p)) - t_j^B(p) + pF(\bar{a}_j(p) - a_j(p)) - I(p).\end{aligned} \tag{21}$$

The FOC which implicitly defines the probability of inspection p^B in the *block* case is

$$\begin{aligned}(1+\alpha_i)\left(\frac{\mathrm{d}a_i^B}{\mathrm{d}p} + \frac{\mathrm{d}a_j^B}{\mathrm{d}p}\right)B'(a_i^B + a_j^B) - C'(a_i^B)\frac{\mathrm{d}a_i^B}{\mathrm{d}p} - \frac{dt_j^B}{dp} \\ + F(\bar{a}_j^B - a_j^B) + p\left(\frac{d\bar{a}_j^B}{dp} - \frac{\mathrm{d}a_j^B}{\mathrm{d}p}\right)F'(\bar{a}_j^B - a_j^B) = \frac{dI}{dp}.\end{aligned} \tag{22}$$

The next step is to compare the outcomes of the block and no-block cases. The outcomes of interest are the levels of total negotiated abatement $\bar{A}$ and total abatement

[24]The negotiation power γ_j could be lower in the block case as compared to the no-block case. However, for the sake of comparison of the variables of interest between the block and the no-block scenarios, in the numerical simulations we keep the same values for this parameter in the two scenarios.

effort A. It is not possible to analytically undertake this comparison at the equilibrium of the game, and for the general functional forms. To overcome this difficulty, we include three simplifications. First, we consider the case of the quadratic benefit and cost functions, used also in the numerical simulations in section 4. We use quadratic functional forms for the abatement benefit and cost functions and the costs of inspection, and a linear penalty function as in the rest of the paper,

$$B(a_i + a_j) = b_1(a_i + a_j) - \frac{b_2}{2}(a_i + a_j)^2 \tag{23}$$

$$C(a_k) = \frac{c}{2}a_k^2, \quad k = i, j, \tag{24}$$

$$I(p) = \frac{g}{2}p^2, \tag{25}$$

$$F(m_k) = fm_k, \text{ with } m_k = \bar{a}_k - a_k \text{ for } k = i, j, \tag{26}$$

with b_1, b_2, $c, g, f > 0$.

Second, we conduct a comparative analysis at the sub-game equilibrium of the game for a given inspection probability. Third, we assume that in either group, fraud in transfers is missing, i.e., $\lambda_i = \lambda_j = 0$. Proposition 4 compares the sub-game equilibrium levels for the total negotiated abatement and the total abatement effort, at the second and third stages of the game, between the block and no-block scenarios. It provides sufficient conditions for the superiority of the total negotiated abatement and the total abatement effort in the block scenario compared to the no-block scenario.

Proposition 4 (Comparison of block vs. no-block scenarios): *For the quadratic case, the absence of fraud in transfers and for a given inspection probability, comparing the outcomes of the total negotiated abatement and the total abatement effort, gives the following results:*

1. $A^B > A^{NB}$ if $p^B > 2p^{NB}$ and $(b_1c - fb_2) > 0$.
2. $\bar{A}^B > \bar{A}^{NB}$ if $(b_1c - fb_2\alpha_i + 1/\alpha_i) > 0$.

Proof : See the online appendix, section B5. □

In the third-stage of the game, the total abatement effort in the block case is higher than that in the no-block case when two sufficient conditions are met. First, the inspection probability must be higher in the former case, i.e., $p^B > 2p^{NB}$. Second, the ratio b_1/b_2 must exceed the ratio f/c. This holds if the coefficient b_1 is sufficiently large, a condition that is also required for the positivity of the marginal benefits from total abatement $(b_1 - b_2A) > 0$. In the second-stage of the game, the total negotiated abatement in the block case is higher than that in the no-block case when the following sufficient condition is met: $b_1/b_2 > f/c((\alpha_i + 1)/\alpha_i)$. Again, this holds if the coefficient b_1 is sufficiently large. Differently from the first result, here the condition does not depend on the level of inspection probability, but it is stricter because $(\alpha_i + 1)/\alpha_i > 2$.

3.5. Governance regime

In the scenario in which the EU is a Party to the Bucharest Convention, at the start of the game player i decides whether to delegate its power of decision to the EU. This happens if the payoff for player i in the block equilibrium exceeds the payoff in the no-block equilibrium. Let $\delta \in [0, 1]$ be the share of the payoff allocated to player i from the total payoff of the block. Thus, player i's decision to delegate is given by: $U_i^B = \delta U_L > U_i^{NB}$. Hence, if $\delta > U_i^{NB}/U_L$, then i agrees to relinquish its decision power to the EU. However, for the delegation to also be accepted by the EU, it must also earn more than in the no-block case, i.e., $U^B = (1-\delta)U_L > U^{NB}$. Thus, delegation takes place if the share of the gains allocated to player i satisfies

$$\frac{U_i^{NB}}{U_L} < \delta < \frac{U_L - U^{NB}}{U_L}. \tag{27}$$

4. Numerical simulations

In order to analyze the welfare of the players and understand their preferences for one or the other institutional arrangement, we rely on numerical simulations for the case of the quadratic benefit and cost functions, and a linear penalty function described for Proposition 4. In the online appendix, section B, we give the analytical forms for the equilibrium values of the variables in the quadratic model, for all scenarios. For the payoff functions in each scenario, we need to impose conditions such that the example meets the general assumptions introduced in section 2. The first condition is that the marginal benefit of total abatement is positive, $B^{'}(A) > 0$, i.e., $(b_1 - b_2A) > 0$. A similar condition holds for the total negotiated abatement, $B^{'}(\bar{A}) > 0$, i.e. $(b_1 - b_2\bar{A}) > 0$. We also check that the objective function in the first stage of the game is concave $d^2U/dp^2 < 0$, and focus on interior solutions $0 < p < 1$. Next, we ensure that the abatement levels and the transfers are positive. Finally, although theoretically relevant, we exclude cases of over-compliance since they are rather unrealistic in the Black Sea case and we focus instead on cases where $f(\bar{a}_k - a_k) > 0$. However, in online appendix B6, we characterize the over-compliance cases analytically.

Before moving to numerical simulations on welfare, we provide some comparative statics on transfer levels in the no-block case. If the marginal abatement cost (c) increases and the marginal inspection cost (g) decreases, the transfer receipts t_i^{NB} and t_j^{NB} increase. This is intuitive: higher abatement costs of the coastal countries require higher compensation and lower inspection costs increase the compensation possibility reflecting a trade-off in the costs borne by the EU. Also and as expected, the stronger relative bargaining power of player j with respect to the EU in one negotiation (λ_j), compared to the relative bargaining power of player i with respect to the EU in the other negotiation (λ_i), increases the transfer receipt of player j at the expense of the transfer receipt of player i. In contrast, higher marginal benefits from total abatement for player j (parameter α_j) decrease the transfer receipt of player j to the advantage of the transfer receipt of player i. This is because player j now needs less compensation since it enjoys larger benefits from abatement already in the non-cooperative situation.

Ideally, for the numerical simulations, our parameter values would be informed by the literature on the Black Sea pollution problem. However, in contrast with the Baltic Sea for which there is an abundant literature in environmental science studying the problem of eutrophication – thus providing parameter estimates for numerical simulations – this literature does not exist in the case of the Black Sea. This difficulty is also underlined in Moxey (2012:16), citing Borysova *et al.* (2005): *"Partial estimates of eutrophication costs in the Black Sea are available, although apportioning contributions* *between neighbouring countries and different sectors is difficult."* To overcome this difficulty, we carry out systematic simulations by considering a large number of parameter constellations.

In what follows, we consider the following set of numerical values of the parameters of the model, namely: $b_1 = 10$; $f = 1$; $\alpha_i = 0.5$; $\alpha_j = \{.33, .43\}$; $g = \{2, 3, \ldots, 10\}$; b_2, $c = \{1, 2\}$; γ_i, $\gamma_j = \{.2, .3, .4\}$; λ_i, $\lambda_j = \{0, .1, .2, .3, .4\}$; $\delta = \{.1, .2, .3, \ldots, 1\}$.[25] All possible combinations of these values give our total number of parameter constellations, which consists of 162,000 different combinations. Out of all these combinations, only 67,320 satisfy the assumptions of the model, namely the conditions discussed in the previous paragraph.

4.1. Scenario choice and gains from cooperation

4.1.1. Simple numerical examples

Before carrying out systematic simulations, we consider simple examples to illustrate some of our results. In the baseline, we consider the following parameter constellations: $b_1 = 10$; $\alpha_i = 0.5$; $\alpha_j = 0.33$; $g = 4$; $b_2 = c = f = 1$; $\gamma_i = \gamma_j = 0.2$; $\lambda_i = \lambda_j = 0.1$; $\delta = \{.1, .2, .3, \ldots, 1\}$. First, we consider more corruption in coastal countries, which corresponds to larger fraud in transfers: $\lambda_i = \lambda_j = 0.2$. Second, we consider lower benefits from abatement for all countries, i.e. $b_1 = 1$. Third, we consider lower penalty to non-compliant coastal countries, i.e., $f = 0.1$. Table C3 in the online appendix summarizes the results of the gains from cooperation, i.e., the change in welfare in cooperative equilibria compared to status quo.

Some observations follow. First, all coastal countries prefer cooperation with the EU to non-cooperation. The individual payoffs of both player i and j are larger than those obtained in the status quo. As expected, cooperation with the EU induces more abatement efforts from coastal countries. The total abatement increases compared to that at the status quo. Third, the EU may be worse off in cooperation, depending on the delegation regime and on the parameter constellations. In the next section, we carry out systematic simulations to check the robustness of these results and investigate new ones.

4.1.2. Systematic simulations

First, we investigate the choice of a governance regime, delegation versus non-delegation. In only a few cases, i.e., approximately 5 per cent of all simulated cases, player i and the EU agree on the choice of a governance regime.

Table C1 in the online appendix reports that in 730 cases, i.e., approximately 1 per cent of all simulated cases, they are better off in terms of individual welfare in the delegation case compared to the no-delegation case. The reverse holds for 66,590 cases or about 99 per cent of all simulated cases. Hence, in the majority of the simulations, delegation does not take place since it is in neither of the two players' interests to form a power block. In the remaining cases, player i and the EU have opposite preferences with respect to the type of governance regime. In particular, player i prefers the block arrangement in approximately 70 per cent of cases while the EU prefers this arrangement in about 27 per cent of cases. Finally, player j is always better off in the delegation regime compared to the no-delegation regime.

[25]At the end of this section, for robustness check, we also provide the results considering other sets of parameter constellations.

These results show that in the case of the EU being a Party to the Convention, Bulgaria and Romania, represented by player *i*, would be better off delegating their decision power to the EU rather than retaining voting rights. In the majority of cases, player *i* prefers the delegation regime because even though this involves a higher level of abatement, player *i* benefits from a cleaner environment and pays no penalty. Player *j* also prefers the delegation regime, which is a more striking result. On the one hand, it is induced to agree to a more ambitious abatement target due to the larger mitigation sensitivity of its negotiating partner. On the other hand, in the compliance stage it abates less than previously, and free rides on the increased abatement effort of player *i* (leakage). Moreover, it receives a larger monetary transfer thanks to the higher abatement target agreed in the negotiations. Regarding the EU, it is frequently worse off in the delegation regime because, although it obtains larger benefits from a cleaner environment, it has to pay significant amounts of monetary transfers to player *j* and receives comparatively lower expected penalties for under-compliance.

Second, for each cooperative equilibrium we investigate the gains from cooperation in order to analyze the position of the coastal countries towards the EU membership. For each player, we examine the difference in payoffs between cooperation and non-cooperation represented by the status quo. Table C2 in the online appendix shows that in the no-delegation equilibrium, the individual payoff of player *i* is always larger than that obtained in the status quo. This also holds for player *j* in 66,570 of the 66,590 cases of our parameter constellations satisfying the assumptions of the model. In the case of the delegation equilibrium, we obtain a similar result. In all 740 cases in which the EU and player *i* agree on the delegation regime, the individual payoffs of all coastal countries exceed the respective payoffs in the status quo. This is related to the fact that in the case of cooperation with the EU, countries partially internalize the negative externality from emissions and abate in a collective manner. The resulting environmental benefits and transfer receipts compensate for the larger abatement costs and the penalty payments for under-compliance by the coastal countries. This result means that cooperation with the EU pays off for both groups of countries. Next we investigate whether this is in the interest of the EU.

We observe that in both regimes, the EU is not always better off than in the status quo. In the no-delegation equilibrium, in only 468 out of 66,590 cases (0.7 per cent) is the EU better off compared to the status quo. In the delegation equilibrium, the results are mixed: in 240 out of 730 cases (33 per cent), the EU is better off relative to the status quo. These cases might explain why the EU is pushing to join the Bucharest Convention. If it assumes decision power from the two MSs, then its welfare improves compared to the current situation represented by the status-quo scenario. In this case the benefits to the EU of being inside the Convention in terms of larger abatement benefits and penalty receipts for under-compliance compensate for the EU's costs of inspection and transfer payments. As already noted however, the delegation equilibrium is difficult to achieve since the MSs and the EU rarely agree about the governance regime.

Next, we summarize several sensitivity analyses that prove the robustness of the above qualitative results. First, we allow the costs of monitoring the MSs and the non-MSs to differ for the EU. We posit that it is more costly to the EU to inspect the abatement compliance of non-MSs than that of the MSs. This change does not affect any of our qualitative results. Now the EU is better off in the cooperative scenarios than in the status quo in a slightly smaller proportion of cases. This result is explained by the larger inspection costs incurred by the EU.

Second, we consider a higher sensitivity to total pollution of the coastal MSs. This change does not affect any of our qualitative results. The most important change is that now the EU is better off in the delegation regime than in the status quo in a larger proportion of cases. This result is explained by the increased abatement benefits due to a larger total abatement triggered by the higher sensitivity to pollution of the coastal MSs.

Third, we assume that the large player values environmental quality less than do the coastal countries, i.e., $\alpha_i > \alpha_j \geqslant 1$. In the no-delegation equilibrium (delegation equilibrium never occurs), coastal countries are better off than in the status quo: they improve their payoffs with cooperation relative to the non-cooperative situation. Thus, larger abatement benefits for the coastal countries do not help explain the resistance of the non-MSs coastal countries to the EU accession.

Finally, we consider the bargaining power of the coastal countries relative to the EU as higher, which is a less likely scenario. This is the only change which implies different qualitative results. In the no-delegation regime (delegation equilibrium never occurs), the EU always loses relative to the status quo because the EU now has a smaller slice of the negotiation cake due to its relatively lower bargaining power. In the majority of cases, this now holds also for the coastal countries, although they have relatively higher bargaining power.

4.2. The effect of misuse of funds

In this section, we investigate how the levels of fraud in the two groups of countries, λ_i and λ_j, affect the EU's decision about the frequency of inspection p and the levels of the negotiated transfers, both in the no-block and the block scenarios. Because closed-form solutions cannot be found for the transfers and for the probability of inspection, we use graphical representations of the data obtained through the simulations described in the previous paragraph to perform comparative statics. For this, we use the following set of parameters: $b_1 = 10$, $b_2 = 1$, $\alpha_i = 0.5$, $\alpha_j = 0.33$, $f = 1$, $g = 5$, $\gamma_i = 0.4$, $\gamma_j = 0.4$ and we consider both a low ($c = 1$) and a high ($c = 2$) marginal abatement cost. The graphs are presented in online appendix D.

Figure D1 (online appendix) depicts this comparative statics for the negotiated transfers for low and high marginal abatement costs, respectively, and for the no-block scenario (top panel) and the block scenario (bottom panel). The figure shows that in the no-block case, the transfer to each group of countries decreases with own level of fraud, and increases with the fraud in the other country group. Similarly, in the block scenario the transfer to player j decreases in its level of misuse of funds. The intuition for this is simple: the transfer of funds towards a country with a high fraud level is reduced in order to minimize losses. At the same time, in the no-block case, these transfers are re-directed towards the other country, hence the increase of the transfers in the level of fraud of the other player.

Figure D2 in the online appendix shows the comparative statics for the inspection probability with respect to λ_i and λ_j, for low and high marginal abatement costs, respectively, and for the no-block scenario (top panel) and the block scenario (bottom panel). The figure shows that for the no-block scenario, the probability of inspection increases in both levels of fraud, while for the block scenario the probability of inspecting player j, the only inspected player in this scenario, decreases in its level of fraud. For the no-block scenario, the result is intuitive, because a high level of fraud can indicate higher non-compliance with the negotiated abatement, hence a higher benefit from inspection for the large player. For the block scenario, the result is, however, less intuitive, but the explanation lies in the effect of a higher fraud on the negotiated abatement level between the EU and player *j*. An increase in the misuse of funds by player *j* induces a decrease in the negotiated abatement standard for that player. In this case, the EU has lower incentives to increase its inspection probability because it expects low penalty receipts from this player for under-compliance. The reduced negotiated abatement also leads to low benefits from abatement for the large player. Note also that the structure of the game is different compared to the no-block scenario. Importantly, the large player does not only incur negotiation and enforcement costs, but also abatement costs. Hence, the large player saves on inspection costs by reducing the frequency of inspection.

5. Conclusion

This paper analyzed the different positions of two groups of coastal countries, EU MSs vs non-MSs, relative to EU accession to the Bucharest Convention, employing a negotiation model of transboundary pollution, with endogenous enforcement and exogenous fraud. We identified the incentives of the groups of countries to form cooperative agreements with the EU. Apart from the status-quo scenario in which the EU is not a Party to the Convention, we investigated two cooperative scenarios in which the EU is a Party, but which differ according to the distribution of authority between the EU and the two MSs. In the first cooperative scenario, the decision power is retained by the coastal countries, i.e., the no-delegation scenario. In the second cooperative scenario, the EU decides the abatement efforts on behalf of the EU MSs, i.e., the delegation scenario. In both cases we assumed that the EU can negotiate and enforce, via a mechanism of control and verification, certain abatement levels on both groups of coastal countries.

The theoretical insights of our model show, on the one hand, that while the enforcement mechanism indeed increases the abatement levels of all countries compared to the status quo, at the strategic level there is emission leakage between the two country groups for both the negotiated and the actual abatement. On the other hand, in our common knowledge setting, the results show that the fraud in compensatory transfers by the recipient coastal countries decreases the ambition of negotiated abatement standards. Further, our theoretical results show that the inspection probability can have both positive and negative effects on the negotiated abatement targets, depending on the existence of fraud in transfers.

To understand countries' preferences for one or the other institutional arrangement, we employed systematic numerical simulations assuming quadratic benefit and cost functions. These results must be regarded with caution as they are not based on real-data calibration, due to the absence of harmonized environmental data for the coastal countries of the Black Sea. Nevertheless, using a large set of parameter values makes it possible to obtain qualitative results in terms of welfare comparison between alternative institutional arrangements.

The results show that cooperation with the EU pays off for both groups of countries. Large environmental benefits due to higher abatement and transfer receipts compensate for the larger abatement costs and penalty payments for under-compliance by the coastal countries. The result of this cost-benefit analysis implies that the non-MSs coastal countries have no economic reason to oppose EU accession to the Bucharest Convention; were they to allow the EU to join the Convention, they would be better off than in the status quo. However, this deal requires receipt of monetary transfers from the EU. Therefore, we investigated whether these arrangements would also be in the interests of the EU.

In both governance regimes, we found that the EU is not always better off compared to the status quo; however, it is more often better off in the delegation than in the no-delegation equilibrium. These results suggest that the desire of the EU to become a Party to the Bucharest Convention may be linked to assuming the decision power of Romania and Bulgaria. However, the delegation equilibrium is difficult to achieve since the MSs and the EU rarely agree about the governance regime. In our analysis we considered only environmental factors and excluded other economic benefits related to geo-strategic issues. From an EU perspective, accession to the Bucharest Convention might pass the cost–benefit test more easily if we included other economic benefits such as access to energy resources in this geographic region and the related reduced energy dependency.

Finally, some caveats of our model are worth mentioning. First, as mentioned in the introduction, the two coastal EU MSs, Romania and Bulgaria, are required by EU regulations, such as the Marine Strategy Framework Directive and Water Framework Directive, to take actions to protect the marine environment. An explicit account for the interaction of the multiple policies can be an interesting avenue for future research. Second, the grouping of the countries according to the EU membership fails to capture the free-riding problems that may occur within a group of countries. The case of multiple players and the possibility of a stable coalition formation among the coastal countries also seems a worthwhile direction to pursue.

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Competing interest. The authors declare none.

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