With or Without the European Union: the Convention for the Protection of the Black Sea Against Pollution

Preliminary version

Abstract

The Black Sea is an enclosed sea surrounded by six coastal countries, two of which (Romania and Bulgaria) are EU Member States. The Convention for the Protection of the Black Sea against Pollution, also known as the Bucharest Convention, was ratified by 1994 by all coastal countries. The Bucharest Convention is the only European regional sea convention to which the EU is not a Party. While Romania and Bulgaria are in favor of the EU accession to the Convention, Turkey, Russia and the Ukraine have thus far blocked this accession. In this paper, we develop a compliance game with negative externalities to analyze different positions of the coastal countries relative to the EU's accession to the Convention. Our model also helps defining the proposal that the EU could make to the three opposing states such that they accept the EU as a Party to the Convention. In the context of the EU being a Party, we also investigate whether Romania and Bulgaria may be better off delegating their power of decision to the EU, rather than keeping their individual voting rights.

1 Introduction

The Black Sea is an enclosed sea situated in the South-East part of Europe and surrounded by six coastal states (Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine) out of which only two states, Bulgaria and Romania, are members of the European Union (EU). The Black Sea has been recognized not only as a significant biodiversity asset, but also as a region of critical economic and strategic importance. The Black Sea area has always been an important transportation hub, being on the transit route of major gas and oil exporters (European Environment Agency 2015). Moreover, the Black Sea is an important energy asset due to the reserves of hydrogen sulfate, gas and oil laying in its depth.

Despite its importance, the media and research publications from the late 1980s and the beginning of the 1990s have qualified the Black Sea as the "most threatened sea in the world"' (Velikova & Oral 2012). This fact triggered the involvement of the United Nations Environmental Program, which in 1992 established the Commission on the Protection of the Black Sea against Pollution. Since then, the Commission has been the major cooperation structure for the protection of the Black Sea, being responsible for the implementation of the Convention on the Protection of the Black Sea against Pollution and its protocols. Also referred to as the Bucharest Convention, it was signed on April 21, 1992 and entered into force on January 15, 1994 after all six coastal countries, as parties to the Convention, ratified it.

The Black Sea faces many challenges, but several recent reports on the problems of the Black Sea list eutrophication on the top of its most serious threats (European Environment Agency 2015, Tavitian et al. 2008). Eutrophication is the process of pollution due to over-enrichment of the water with nutrients coming primarily from sources like nitrate fertilizers, nutrients from animal waste and human sewage. As a result, the sea becomes overgrown in algae and other aquatic plants, which, after decomposing, exhaust the water from oxygen, thus killing other living organisms.[1] Eutrophication is primarily caused by nutrient pollutants from land-based sources, such as the agricultural and domestic pollution. In fact, the land-based sources of pollution account for 70% of all pollution in the Black Sea (European Environment Agency 2015). The nutrient pollution could be caused by agricultural, industrial or urban sectors. A study on the Danube River basin countries, which supply a large amount of nutrients to the Black Sea through the Danube river, showed that the agricultural sector was responsible for 50% of nutrient emissions, while industry and the urban sector both had shares of 25% (Black Sea Commission 2002).

Although one of the main challenges addressed by the Bucharest Convention is combating pollution from land-based sources, its effectiveness remains problem-

[1] Definition retrieved from https://www.eionet.europa.eu/gemet/en/concept/3007.

atic. One reason for its current ineffectiveness is that national governments,[2] that should implement the commitments stipulated in the Convention show inadequate political commitment (Tavitian et al. 2008). Even if appropriate laws exist at national levels, their enforcement is not effective due to several reasons: lack of funding, national priorities that do not include environmental protection, weak quality of institutions in the Black Sea countries,[3] and the absence of a compliance instrument in the Convention (European Environment Agency 2015). The current political and military conflicts in the region, especially involving Russia and Ukraine, also create an obstacle to an effective implementation of the Convention. Therefore, the governance of the Black Sea as a socio-ecological system is of great importance for the successful protection of the sea from pollution originating from land-based sources.

It is important to note that the Bucharest Convention is the only European regional sea convention to which the EU is not a party. However, the two EU coastal countries have to meet obligations under the EU regulations (e.g. the EU Marine Strategy Framework Directive), while the other four coastal states need not adhere or comply with the EU measures (Freire-Gibb et al. 2014).[4] This situation creates by design a disproportional contribution of the coastal states to the protection of the sea, as well as a non-uniform distribution of monitoring across these states. Therefore, the governance of the Black Sea bears differences with that of the Mediterranean Sea, the other European sea with non-EU coastal countries, as the EU is indeed a party to the Barcelona Convention.[5] The European Commission sees it as a priority that the Bucharest Convention is amended to allow the EU to accede (Commission of the European Communities 2007). The position of the Permanent Secretariat of the Black Sea Commission is also favorable to

[2]Each Contracting Party shall ensure the application of the Convention in those areas of the Black Sea where it exercises its sovereignty as well as its sovereign rights and jurisdiction without prejudice to the rights and obligations of the Contracting Parties arising from the rules of international law. (Article V of the Convention).

[3]According to Transparency International, the parties to the Convention have Corruption Perception Indices for 2016 between 29 and 57, with 0 meaning high corruption and 100 meaning corruption-clean score. The global average is 43, indicating endemic corruption.

[4]This is a difficulty that also applies to the Mediterranean Sea, but which is absent for the Baltic Sea and the North-East Atlantic.

[5]The Barcelona Convention is the cooperation structure that governs the protection of the marine environment and the coastal region of the Mediterranean Sea.

the EU partnership, as it was expressed by the Commission's representatives with the occasion of a Conference launching the Black Sea Environment Partnership in Brussels, in March 2010.[6]

This seems, however, not to be a simple process as Russia, Turkey and Ukraine have expressed their opposition towards the EU accession to the Convention. Internal documents of the Black Sea Commission on the conclusions of the third meeting of the ad hoc Expert Group on item 8 of the 2009 Ministerial Declaration show that Russia's main concern was with the distribution of the voting rights and decision making between the EU Commission and the two Member States (MSs), Romania and Bulgaria (Makarenko 2014). The oppositions of Turkey and Ukraine had a more diplomatic character and invoked the current text of the Convention that does not foresee the possibility for a Regional Economic Integration Organization, like the EU, to become a Party.

The main objective of this paper is to explain the resistance of the non-MSs (Russia, Turkey and Ukraine) to the EU accession to the Bucharest Convention in a game with negative externalities. Thus, we develop a game-theoretic model that helps defining the proposal that the EU could make to the non-MSs such that these countries accept the EU as a Party to the Convention. This model is also used to investigate the payoffs of the two MSs (Bulgaria and Romania) with the EU accession to the Convention. This will allow us to analyze whether these countries push for the EU accession for economic rather than political reasons. We also investigate whether these countries may be better off delegating their power of decision to the EU, rather than keeping their voting rights.[7] Therefore, apart from the status-quo scenario in which the EU is not a Party, two scenarios are investigated in the paper. In both of these scenarios, the EU is a Party to the Convention, but they differ with respect to the distribution of authority between the EU and the two MSs. The features of each scenario are detailed in the next Section.

[6]Information taken from the speeches of the Commission's representatives retrieved from http://www.blacksea-commission.org/_eubs-env-partnership.asp on October 29, 2018.

[7]It should be noted that in the event of the EU becoming a party to the Convention, there cannot be an increase in voting rights from six to seven. Instead, it is the case that either the EU has two voting rights if the two MSs decide to delegate their decisions to the EU or the two MSs each has one voting right if they decide to keep their decision power.

The paper proceeds as follows. In the next section we discuss the related literature. After introducing the model framework in Section 3, we solve the model for the different scenarios discussed above in Section 4. In Section 5, we consider an example with quadratic functions on which we perform numerical simulations to compare the outcomes of the delegation and non-delegation scenarios, particularly with respect to players' welfare. Section 6 concludes.

2 Related Literature

Our paper is mainly related to three strands of literature. The first one relates to the literature on transboundary pollution problems and international environmental cooperation (see, for example, Barrett 2003, Finus 2008). In game-theoretic modeling, transboundary pollution problems are modeled either as emissions games with negative externalities or abatement games with positive externalities. Regarding flow pollutants, international environmental cooperation is mostly investigated via the coalition formation framework[8] for signing an international environmental agreement (Barrett 1994, Carraro & Siniscalco 1993). Recent contributions to this literature include for instance El-Sayed & Rubio (2014), Battaglini & Harstad (2016), Bayramoglu et al. (2018). Regarding stock pollutants, international environmental cooperation is analyzed with differential games (see for instance Mäler & de Zeeuw 1998, Feenstra et al. 2001, List & Mason 2001).

The literature that investigates transboundary water pollution problems using game-theoretical models is still relatively scarce. Modeling has been applied to different geographical zones: water pollution between Mexico and the U.S. (Fernandez 2002, 2009), regional pollution in a river basin in China (Shi et al. 2016), nutrient pollution problem in the Baltic Sea (Laukkanen & Huhtala 2008, Gren 2001, Gren & Folmer 2003, Laukkanen & Huhtala 2008, Ahlvik & Pavlova 2013) and nutrient pollution problem in the Black Sea (Bayramoglu 2006). Ahlvik & Pavlova (2013) study the problem of cooperation among the Baltic countries to reduce eutrophication in this sea. The authors develop a model of coalition formation and dynamic accumulation of nutrients. Using actual nutrient data, they

[8]This approach is inspired from the cartel formation game in industrial organization (d'Aspremont et al. 1983).

show that an agreement with modest abatement targets between all the coastal countries may be more efficient than a coalition between fewer countries with ambitious targets. Apart from focusing on eutrophication, this research is also related to ours in the sense that it considers the enforcement potential of the EU. The results show that, indeed, the EU has the power to bring about an agreement with full participation and efficient abatement, by enforcing abatement efforts on his members and negotiating with Russia within the Helsinki Agreement.

To the best of our knowledge, Bayramoglu (2006) is the only economics paper that develops a game-theoretical model to study the problem of cooperation in reducing eutrophication of the Black Sea.[9] Studying three different institutional arrangements, the author considers the interaction between only two of the six coastal countries, namely Romania and Ukraine. The differential-game model accounts explicitly for the tradeoff between agricultural production, as source of pollution, and fish production, as victim of pollution. Simulation results of the calibrated model show that Romania would lose by moving away from the non-cooperative solution to the first-best case, while the opposite holds for Ukraine. This means that Ukraine could compensate Romania for moving away from the non-cooperative solution towards a cooperative solution. However, the proposal of the Black Sea Commission of adopting the 1997 emissions target is not preferred by neither of the two countries. Relative to this paper, our contribution is to consider the new political context in which the EU has become a player in the game of pollution mitigation at the Black Sea. In light of this role of the EU we consider explicitly its enforcement power and the problem of compliance by the coastal countries.

Second, because our model includes random monitoring with penalty, the second strand of literature to which our paper relates is that of the compliance models. This literature has been initiated by Becker (1968) on the economic of crime. The setting of this seminal paper has been extensively used in models that analyze tax evasion and compliance (e.g. Allingham & Sandmo 1972, Srinivasan 1973), but also compliance with environmental regulations. For instance, Heyes (2000)

[9]Knowler et al. (2001) and Knowler & Barbier (2005) study the effects of management options in regulating pollution or commercial fish stocks respectively in the Black sea using a dynamic bio-economic model

reviews some of the theoretical (and empirical) literature on compliance and enforcement of environmental regulations to identify some of the ways in which this benchmark model of regulation has been enriched to accommodate alternative assumptions and objectives in the context of regulating polluters.

Finally, our scenario in which the EU is part of the Convention and may decide on behalf of the two MSs appeals to the strategic delegation models, initially developed in the industrial organization literature (Vickers 1985, Fershtman & Judd 1987). These types of models demonstrate how a firm owner can be better off by delegating her power of decision to another agent, typically the manager, who has a different payoff function. The delegation works as a credible commitment device that influences rivals' behavior in a way that benefits the firm's owner.[10] In the context of non-cooperative environmental policy, Roelfsema (2007) shows that if the principal cares sufficiently for the environment, then she delegates policy making to an agent that cares more for the environment than herself, thus reducing the risk of setting too low environmental taxes. Closer to our setting, however, are papers that study the effect of delegation on the bargaining outcome. For instance, Segendorff (1998) studies the strategic delegation problem in the case of the bargaining between two nations over the provision of a public good, assuming different levels of authority given to the agents. The model yields that although both nations would delegate the negotiation task to an agent with a stronger preference for the private good than themselves, they are always better off through self-representation. If delegation should nevertheless take place, little authority should be granted to the agents.

3 Model

We consider the six coastal countries to the Black sea and the large player, i.e. the EU. The set of coastal countries can be partitioned in two groups according to their position towards the large player. Two of the countries, Romania and Bulgaria are EU members and therefore, have similar positions regarding policies that protect the sea against pollution. The two Member States have, in fact, proposed the

[10]A relatively recent review of the theoretical literature on strategic delegation can be found in Sengul et al. (2012).

accession of the EU as a Party to the Bucharest Convention. Moreover, Georgia has expressed its support for the EU's accession. We will, therefore, regard this group of three countries as a single player indexed by i.

The other three countries (Russia, Turkey and Ukraine) are not EU members and have a rather antagonistic position towards the EU's accession. For simplicity of exposition, we will further treat this second group of countries as one player and index it by j. It may be argued, however, that due to the latest political and even military conflicts, Russia and Ukraine should be treated separately. While this may be the case for certain bilateral relations between the two nations, we believe that this is not the case regarding the Bucharest Convention. For the purpose of our model in which we are not concerned with the relation between the two countries, but rather with their position towards the EU accession to the Convention, putting them in the same block seems to be the most pertinent approach, as their expressed position towards the issue at hand is similar (see also the Introduction section).

We assume the following payoff function for player i

$$U_i(a_i, A, \bar{a}_i, t_i, p) = \alpha B(A) - C(a_i) + (1 - \lambda_i)t_i - pF(\bar{a}_i - a_i) \tag{1}$$

and for player j

$$U_j(a_j, A, \bar{a}_j, t_j, p) = \beta B(A) - C(a_j) + (1 - \lambda_j)t_j - pF(\bar{a}_j - a_j), \tag{2}$$

where $B(\cdot)$ is the benefit function of the total abatement efforts $A = a_i + a_j$, which is assumed to be increasing and concave: $B'(A) > 0$ and $B''(A) \leq 0$. This means that the marginal benefit of abatement is (weakly) decreasing. Parameters $\beta < \alpha < 1$ capture the heterogeneity in the preference for the environment among the two groups of countries. Hence, the group opposing the EU's accession is assumed to be less concerned with total pollution than the group of countries that favor the EU's accession. $C(\cdot)$ is the abatement cost function which is assumed to be increasing and convex, $C'(\cdot) > 0$ and $C''(\cdot) > 0$. This means that the marginal abatement cost is increasing. For simplicity we assume that players are symmetric with respect to the abatement cost efforts. Moreover, t_i and t_j are the transfers received by players i and j, respectively, from the large player. Parameters $\lambda_i, \lambda_j \in [0,1]$ capture the measure of fraud or misuse of transferred funds from the large player and they are allowed to differ between the two groups of countries. The larger the λ's, the higher the level of fraud. Hence, there are two sources of heterogeneity among players i and j: they differ with respect to the benefit from total abatement and to the degree of misuse of transfer receipts.

The last term in (1) and (2) is a penalty function for under-compliance relative to an agreed level of compliance $\bar{a}_k$, 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 $\bar{a}_k - a_k \leq 0$. Denoting $m_k = \bar{a}_k - a_k > 0$ the level of under-compliance, we assume that $F'(m_k) > 0$ and $F''(m_k) \geq 0,\ k = i, j$. Finally, $p \in [0,1]$ is the inspection probability, which is costly to be conducted by the large player (the EU). Let the inspection cost be $I(n,p) = nI(p)$, $n \in \{1,\, 2\}$ such that $I(0) = 0$, $I'(p) > 0$ and $I''(p) > 0$.

We are now ready to define the payoff function of the large player:

$$\begin{gathered} U(a_i, a_j, A, \bar{a}_i, \bar{a}_j, t_i, t_j, p) = \\ B(A) - t_i - t_j + p\left[F(\bar{a}_i - a_i) + F(\bar{a}_j - a_j)\right] - nI(p), n \in \{1,\, 2\}. \end{gathered} \tag{3}$$

Note that the large player cares more about the environment than any of the individual players. Apart from benefit from total abatement, the large player also derives payoffs from the penalty charged for under-compliance with respect to the negotiated levels from both players. It also incurs costs for monetary transfers paid to the coastal countries.

4 Scenarios

We investigate three scenarios that differ with respect to the position of the large player (the EU) in the Convention. 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, while in reality the EU makes transfers to the coastal countries even in the status quo, we assume that if this happens, the transfer payment is for other purposes and is thus outside the decision framework of our model. Therefore, $t_i = t_j = 0$

and the status-quo scenario corresponds to the Nash equilibrium, in which each player decides the individual abatement level to maximize its own payoff.

The second scenario, called the *no-block* scenario, is that in which the large player is a Party to the Convention, but the MSs decide their individual abatement levels on their own, i.e. the EU does not form a decision block with the MSs. Hence 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 inspection probability.
- Stage 2: The large player negotiates separately with each of the two players on the levels of abatement and transfers.
- Stage 3: Each player decides on its compliance level.

At the last stage of the game, the inspection takes place and the large player applies the fine according its penalty function.

It is worthwhile noting first the interaction between stages 2 and 3. The current levels of negotiated abatement standards and transfers will affect the compliance level of each player. Intuitively, if the negotiated abatement standards increase, the compliance should increase too to avoid the payment of a high penalty, i.e. $\frac{\partial a_i}{\partial \bar{a}_i} > 0$. Likewise, the anticipated level of future abatement compliance has an impact on the current outcomes of negotiation. Intuitively, if the anticipated compliance is high, the large player would have an incentive to increase the negotiated standard in order to raise the receipt of penalty.

Stages 1 and 2 of the game are related to the policy choice of the large player, in particular. The large player has three instruments at its disposal: the inspection probability and the levels of negotiated abatement standards and transfers. It can use all of these instruments (we exclude corner solutions where the EU does not inspect due to very large inspection costs) to maximize its payoff function. As regards the interaction between stages 1 and 2, the level of inspection probability chosen at stage 1 will affect the negotiated abatement standards and transfers decided at stage 2 of the game. Likewise, the anticipated level of future outcomes of negotiation will affect the choice of inspection probability. The question is whether negotiation variables and inspection are substitute or complementary strategies for the large player. In case these strategies are substitutes, we would have $\frac{\partial \bar{a}_i}{\partial p} < 0$ and $\frac{\partial t_i}{\partial p} < 0$; when they are complements, we would have $\frac{\partial \bar{a}_i}{\partial p} > 0$ and $\frac{\partial t_i}{\partial p} > 0$. As inspection and transfer payments are costly for the EU to undertake, at first sight, we expect that these two strategies are substitutes. We will study these comparative statistics in detail in the following analysis.

The third scenario we consider is the *block* scenario. This scenario is identical with the *no-block* one, except that instead of deciding itself the level of abatement, player i, may delegate this decision to the large player. Hence, before the game is played as described in the *no-block* scenario, player i decides whether or not to delegate the abatement decision to the large player.

For each of the three scenarios described above the game is solved by backwards induction. We start by solving the non-cooperative case (the status-quo scenario) that serves as the threat point for the negotiations that occur in the other two scenarios.

4.1 Status-quo

We assume that the players choose Nash equilibrium strategies when they do not cooperate. The objective of each player is to maximize its own payoff, taking the abatement level of the other player as given. The first-order conditions give:

$$B'(A) = \frac{C'(a_i)}{\alpha} = \frac{C'(a_j)}{\beta}. \tag{4}$$

The solution to this system of equations gives a_i^{SQ} and a_j^{SQ}, where SQ stands for *status quo*. Since $\beta < \alpha$, it is clear from (4) that $a_i^{SQ} > a_j^{SQ}$. The resulting payoff levels, obtained by plugging the resulting equilibrium levels into (1), (2) and (3) are denoted by U_i^{SQ}, U_j^{SQ} and U^{SQ}, for the two players and the large player, respectively.

4.2 Full-cooperative solution

In the full-cooperative solution the planner maximizes the sum of all players' payoff and there is no issue of compliance and, consequently, no verification and no misuse of the transfer funds. Thus, the objective of the planner is:

$$\max_{a_i,a_j} W = (1+\alpha+\beta)B(A) - C(a_i) - C(a_j). \tag{5}$$

The first order conditions with respect to each of the abatement levels are:

$$B'(A) = \frac{C'(a_i)}{1+\alpha+\beta} = \frac{C'(a_j)}{1+\alpha+\beta} \tag{6}$$

Given that the marginal cost function is strictly increasing, equation (6) implies that $a_i = a_j$. Moreover, comparing (6) with (4), it also becomes apparent that the individual abatement levels are higher than in the SQ case for each player. Consequently, the total abatement is higher in the full-cooperative solution than in the SQ.

4.3 EU Accession without the EU Block

In the third stage, the two players choose their abatement levels non-cooperatively, taking into account the inspection probability p decided at Stage 1 and the negotiated abatement level $\bar{a}_i$ decided at Stage 2. The problem solved by player i is:

$$\max_{a_i} U_i(a_i, A) = \alpha B(a_i + a_j) - C(a_i) + (1-\lambda_i)t_i - pF(\bar{a}_i - a_i), \tag{7}$$

and the first-order condition with respect to a_i reads:

$$B'(A) = \frac{C'(a_i) - pF'(\bar{a}_i - a_i)}{\alpha}. \tag{8}$$

The second-order condition is verified following the assumed concavity of the relevant functions, i.e. $\alpha B''(A) - C''(a_i) - pF''(\bar{a}_i - a_i) < 0$.

Similarly for player j we have

$$B'(A) = \frac{C'(a_j) - pF'(\bar{a}_j - a_j)}{\beta}, \tag{9}$$

with the associated second-order condition, $\beta B''(A) - C''(a_j) - pF''(\bar{a}_j - a_j) < 0$.

Solving the system of equations (8) and (9) 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 stands for *no-block*. These, then, correspond to the payoffs U_i^{NB}, U_j^{NB} and U^{NB}, respectively.

The following proposition can be established:

Proposition 1. *The inspection probability induces a higher level of abatement compared to the status quo, i.e.* $a_k^{NB} > a_k^{SQ}$, *for* $k = i, j$.

Proof. Comparing Equation 4 with Equations 8 and 9, it follows that the inspection probability induces a higher level of abatement, i.e. $a_i^{NB} > a_i^{SQ}$ and $a_j^{NB} > a_j^{SQ}$. □

Proposition 2 (**Slopes of Reaction Functions in Abatement Compliance**).

1. *[(i)]*

2. *The slope of the reaction function in compliance space* $a_i = f_i(a_j)$ *is given by*
$$f_i'(a_j) = \frac{-\alpha B''(A)}{\alpha B''(A) - C''(a_i) - pF''(\bar{a}_i - a_i)}.$$
Hence it is (weakly) downward sloping as $B''(A) \leq 0$.

3. *The slope of the reaction function in compliance-own negotiated standard space* $a_i = g_i(\bar{a}_i)$ *is given by*
$$g_i'(\bar{a}_i) = \frac{-pF''(\bar{a}_i - a_i)\left(\beta B''(A) - C''(a_j) - pF''(\bar{a}_j - a_j)\right)}{\left(\beta B''(A) - C''(a_j) - pF''(\bar{a}_j - a_j)\right)\left(\alpha B''(A) - C''(a_i) - pF''(\bar{a}_i - a_i)\right) - \alpha\beta\left(B''(A)\right)^2}.$$
Hence, the reaction function is (weakly) upward slopping as $F''(\bar{a}_i - a_i) \geq 0$

4. *The slope of the reaction function in compliance-others' negotiated standard space* $a_i = h_i(\bar{a}_j)$ *is given by*

$$h_i'(\bar{a}_j) = \frac{\alpha B''(A) p F''(\bar{a}_j - a_j)}{\left(\beta B''(A) - C''(a_j) - pF''(\bar{a}_j - a_j)\right)\left(\alpha B''(A) - C''(a_i) - pF''(\bar{a}_i - a_i)\right) - \alpha\beta \left(B''(A)\right)^2}.$$

Hence it is (weakly) downward sloping as $F''(\bar{a}_j - a_j) \geq 0$ *and* $B''(A) \leq 0$.

Proof. The first expression in (i) is found using the total differential of condition (8) given $d\bar{a}_i = 0$ and $dp = 0$. The expressions in (ii) and (iii) are found using the total differentials of conditions (8) and (9) altogether given $dp = 0$. The signs of g' and h' are determined by taking into account that the denominators are positive. Hence, the total sign of these slopes depend solely on the sign of the numerators. □

The first statement sheds light on whether abatement compliance levels are strategic substitutes or complements. In this game, they are always substitutes (leakage) if we exclude the case $B''(A) = 0$ in which case the reaction functions are orthogonal. The second statement relates to whether compliance and own negotiated standard are substitutes or complements. They are always complements if the second derivative of the penalty function $F''(\bar{a}_j - a_j)$ is positive. This shows that the higher the negotiated abatement standard, the higher is the compliance level to avoid the payment of a high penalty, i.e. $\frac{\partial a_i}{\partial \bar{a}_i} > 0$. The compliance is independent of the negotiated level of abatement when the penalty function is linear, i.e. $F''(\bar{a}_j - a_j) = 0$. The third statement indicates that compliance and other player's negotiated standard are always substitutes if we exclude the cases of linear benefit and penalty functions: $B''(A) = 0$ and $F''(\bar{a}_j - a_j) = 0$. This finding is related to the first two results. When player j negotiates a higher abatement standard, its compliance level increases,which induces a decline in the abatement effort of player i due to leakage.

In the second stage, the large player negotiates separately with each of the small players to determine the abatement targets $\bar{a}_i$ and $\bar{a}_j$, anticipating the compliance levels from the third stage and taking into account the inspection probability from the first stage. To determine the outcome of negotiations, we use a Nash bargaining solution in which the surplus is split via transfers, according to parties' bargaining power, and in which the threat point is given by the status-quo. Thus, the parties maximize the Nash product:

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

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

The first order condition with respect to $\bar{a}_i$ is

$$\left[\alpha B'(\bar{a}_i+\bar{a}_j) - C'(\bar{a}_i) - p\left(1-\frac{da_i^{NB}}{d\bar{a}_i}\right)F'\left(\bar{a}_i - a_i^{NB}(\bar{a}_i,\bar{a}_j)\right)\right]\frac{\gamma_i}{U_i - U_i^{SQ}} +$$
$$\left[B'(\bar{a}_i+\bar{a}_j) + p\left(1-\frac{da_i^{NB}}{d\bar{a}_i}\right)F'\left(\bar{a}_i - a_i^{NB}(\bar{a}_i,\bar{a}_j)\right) - p\frac{da_j^{NB}}{d\bar{a}_i}F'\left(\bar{a}_j - a_j^{NB}(\bar{a}_i,\bar{a}_j)\right)\right]\frac{(1-\gamma_i)}{U-U^{SQ}} = 0 \tag{10}$$

and with respect to t_i is

$$\frac{U-U^{SQ}}{U_i - U_i^{SQ}} = \frac{1-\gamma_i}{\gamma_i(1-\lambda_i)}, \tag{11}$$

which substituted in (10) gives the following, after some algebraic manipulations:

$$B'(\bar{a}_i+\bar{a}_j) = \frac{C'(\bar{a}_i)}{\alpha+(1-\lambda_i)} +$$
$$\frac{p\left[\lambda_i\left(1-\frac{da_i^{NB}}{d\bar{a}_i}\right)F'\left(\bar{a}_i - a_i^{NB}(\bar{a}_i)\right) + (1-\lambda_i)\frac{da_j^{NB}}{d\bar{a}_i}F'\left(\bar{a}_j - a_j^{NB}(\bar{a}_i,\bar{a}_j)\right)\right]}{\alpha+(1-\lambda_i)} \tag{12}$$

Analogously, for j we have:

$$B'(\bar{a}_i+\bar{a}_j) = \frac{C'(\bar{a}_j)}{\beta+(1-\lambda_j)} +$$
$$\frac{p\left[\lambda_j\left(1-\frac{da_j^{NB}}{d\bar{a}_j}\right)F'\left(\bar{a}_j - a_j^{NB}(\bar{a}_j)\right) + (1-\lambda_j)\frac{da_i^{NB}}{d\bar{a}_j}F'\left(\bar{a}_i - a_i^{NB}(\bar{a}_i,\bar{a}_j)\right)\right]}{\beta+(1-\lambda_j)} \tag{13}$$

Solving the system of equations formed by (12) and (13), we obtain the negotiated levels of abatement under the scenario "without the EU block", as functions of the inspection probability decided in stage 1 of the game: $\bar{a}_i^{NB} = \bar{a}_i(p)$ and $\bar{a}_j^{NB} = \bar{a}_j(p)$.

We now simplify these FOCs by assuming a linear penalty function, i.e. $F'' = 0$. In this case, we know from Proposition 2 that, $\frac{da_i^{NB}}{d\bar{a}_i} = \frac{da_j^{NB}}{d\bar{a}_j} = \frac{da_j^{NB}}{d\bar{a}_i} = \frac{da_i^{NB}}{d\bar{a}_j} = 0$. This leads to the following FOC for country i:

$$B'(\bar{a}_i + \bar{a}_j) = \frac{C'(\bar{a}_i) + p\lambda_i F'\left(\bar{a}_i - a_i^{NB}(\bar{a}_i, \bar{a}_j)\right)}{\alpha + (1 - \lambda_i)} \tag{14}$$

Analogously, for j we have:

$$B'(\bar{a}_i + \bar{a}_j) = \frac{C'(\bar{a}_j) + p\lambda_j F'\left(\bar{a}_j - a_j^{NB}(\bar{a}_i, \bar{a}_j)\right)}{\beta + (1 - \lambda_j)} \tag{15}$$

Lemma 1. *For a linear penalty function and no fraud in the monetary transfers, i.e.* $F'' = 0$ *and* $\lambda_k = 0$*, the negotiated abatement level is identical to that of the status quo situation:* $\bar{a}_k^{NB} = a_k^{SQ}$, $k = i, j$.

Proof. We obtain the result by comparing Equation (4) with Equations (14) and (15) when $\lambda_k = 0$ for $k = i, j$. □

Proposition 3 (Slopes of Reaction Functions in Negotiated Abatement). *For a linear penalty function, i.e.* $F'' = 0$*, the slope of the reaction function in negotiated abatement space* $\bar{a}_i = m_i(\bar{a}_j)$ *is given by*

$$m_i'(\bar{a}_j) = \frac{(\alpha + (1 - \lambda_i))\, B''(\bar{a}_i + \bar{a}_j)}{C''(\bar{a}_i) - (\alpha + (1 - \lambda_i))\, B''(\bar{a}_i + \bar{a}_j)}.$$

Hence it is (weakly) downward sloping as $B''(A) \leq 0$.

Proof. The expression is found using the total differentials of Equations (14) and (15). □

Proposition 3 indicates that the negotiated levels of abatement standards are always substitutes (leakage) if we exclude the case $B''(A) = 0$ in which situation the reaction functions are orthogonal.

Proposition 4. *For a linear penalty function, i.e.* $F'' = 0$, *the negotiated abatement level* a_k, $k = i, j$, *is a decreasing function of the loss in transfer receipts* λ_k. *The relationship is defined by:*

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

Proof. For a linear penalty function, i.e. $F'' = 0$ implying $\frac{da_i^{NB}}{d\bar{a}_i} = \frac{da_j^{NB}}{d\bar{a}_j} = \frac{da_j^{NB}}{d\bar{a}_i} = \frac{da_i^{NB}}{d\bar{a}_j} = 0$, the total differential of Equation (15) assuming $d\lambda_j = 0$ is given by:

$$\begin{aligned} (d\bar{a}_i + d\bar{a}_j)B''(\bar{a}_i + \bar{a}_j)\left(\beta + (1 - \lambda_j)\right) = d\bar{a}_j C''(\bar{a}_j) \iff \\ d\bar{a}_j = d\bar{a}_i \frac{\left(\beta + (1 - \lambda_j)\right) B''(\bar{a}_i + \bar{a}_j)}{C''(\bar{a}_j) - \left(\beta + (1 - \lambda_j)\right) B''(\bar{a}_i + \bar{a}_j)} \end{aligned} \tag{16}$$

Similarly, the total differential of Equation (14) is given by:

$$\begin{aligned} d\bar{a}_i \left[B''(\bar{a}_i + \bar{a}_j)\left(\alpha + (1 - \lambda_i)\right) - C''(\bar{a}_i)\right] + d\bar{a}_j \left[B''(\bar{a}_i + \bar{a}_j)\left(\alpha + (1 - \lambda_i)\right)\right] = \\ d\lambda_i \left[B'(\bar{a}_i + \bar{a}_j) + pF'\left(\bar{a}_i - a_i^{NB}\right)\right] \end{aligned} \tag{17}$$

Solving this system of two equations gives the expression of $\frac{d\bar{a}_i}{d\lambda_i}$. □

Proposition 4 shows that the higher the level of fraud (losses) in the transfers, the lower the resulted negotiated abatement level for the transfer recipient.

Proposition 5 (**Substitute vs. Complementary Policy Variables**). *For a linear penalty function, i.e.* $F'' = 0$, *the slope of the reaction function in negotiated abatement-inspection space* $\bar{a}_i = n_i(p)$ *is given by*

$$n_i^{'}(p) = \frac{-\lambda_i F'(\bar{a}_i - a_i) D_j + \lambda_j F'(\bar{a}_j - a_j) B''(\bar{a}_i + \bar{a}_j)\left(\alpha + (1-\lambda_i)\right)}{C''(\bar{a}_j)\left(\alpha + (1-\lambda_i)\right) B''(\bar{a}_i + \bar{a}_j) + C''(\bar{a}_i) D_j}$$

where $D_j = B''(\bar{a}_i + \bar{a}_j)\left(\beta + (1-\lambda_j)\right) - C''(\bar{a}_j) < 0$. *The sign of the slope is ambiguous.*

Proof. For a linear penalty function, i.e. $F'' = 0$, the total differential of Equation (14) is given by:

$$(d\bar{a}_i + d\bar{a}_j) B''(\bar{a}_i + \bar{a}_j)\left(\alpha + (1-\lambda_i)\right) = d\bar{a}_i C''(\bar{a}_i) + dp \lambda_i F'\left(\bar{a}_i - a_i^{NB}\right)$$

Similarly, the total differential of Equation (15) is given by:

$$(d\bar{a}_i + d\bar{a}_j) B''(\bar{a}_i + \bar{a}_j)\left(\beta + (1-\lambda_j)\right) = d\bar{a}_j C''(\bar{a}_j) + dp \lambda_j F'\left(\bar{a}_j - a_j^{NB}\right)$$

Solving this system of two equations gives the expression of $\frac{d\bar{a}_i}{dp}$. □

Proposition 5 indicates that the two policy variables could be either substitutes or complements for the large player, the EU. Lower losses in transfer receipts give incentives to small players to accept a deal with a higher negotiated abatement standard (see Proposition 4). In this case, large negotiated standards could coexist with high inpection probability. This is the case when inspection and negotiated standard are strategic complements from the point of view of the large player.

The resulting payoffs are: $U_i^{NB}(p)$, $U_j^{NB}(p)$ and $U^{NB}(p)$. Denote $u_i^{NB}(p) = \alpha B(\bar{A}^{NB}) - C(\bar{a}_i^{NB}) - pF(\bar{a}_i^{NB} - a_i^{NB})$, $u_j^{NB}(p) = \beta B(\bar{A}^{NB}) - C(\bar{a}_{ji}^{NB}) - pF(\bar{a}_j^{NB} - a_j^{NB})$ and $u^{NB}(p) = B(\bar{A}^{NB}) + p\left[F(\bar{a}_i^{NB} - a_i^{NB}) + F(\bar{a}_j^{NB} - a_j^{NB})\right]$. With these notations, the transfers are determined from (11) as:

$$t_i(p) = \gamma_i(u^{NB} - t_j^{NB} - U^{SQ}) - \frac{1-\gamma_i}{1-\lambda_i}\left(u_i^{NB} - U_i^{SQ}\right) \qquad (18)$$

Similarly, for player j we have:

$$t_j^{NB}(p) = \gamma_j(u^{NB} - t_i^{NB} - U^{SQ}) - \frac{1-\gamma_j}{1-\lambda_j}\left(u_j^{NB} - U_j^{SQ}\right) \tag{19}$$

Solving these two equations with two unknowns t_i and t_j gives us:

$$t_i^{NB}(p) = \frac{\gamma_i(1-\gamma_j)}{(1-\gamma_i\gamma_j)}(u^{NB}(p) - U^{SQ}) - \frac{(1-\gamma_i)}{(1-\lambda_i)(1-\gamma_i\gamma_j)}\left(u_i^{NB}(p) - U_i^{SQ}\right) + \frac{\gamma_i(1-\gamma_j)}{(1-\lambda_j)(1-\gamma_i\gamma_j)}\left(u_j^{NB}(p) - U_j^{SQ}\right) \tag{20}$$

$$t_j^{NB}(p) = \frac{\gamma_j(1-\gamma_i)}{(1-\gamma_i\gamma_j)}(u^{NB}(p) - U^{SQ}) - \frac{(1-\gamma_j)}{(1-\lambda_j)(1-\gamma_i\gamma_j)}\left(u_j^{NB}(p) - U_j^{SQ}\right) + \frac{\gamma_j(1-\gamma_i)}{(1-\lambda_i)(1-\gamma_i\gamma_j)}\left(u_i^{NB}(p) - U_i^{SQ}\right) \tag{21}$$

Finally, in the first stage the large player decides on the inspection probability p. For this, the large player maximizes (3) with respect to p, anticipating the compliance and negotiated levels of abatement. The first order condition with respect to p is:

$$\left(\frac{da_i^{NB}}{dp} + \frac{da_j^{NB}}{dp}\right) B^{'}(a_i^{NB} + a_j^{NB}) - \frac{dt_i^{NB}}{dp} - \frac{dt_j^{NB}}{dp} + F(\bar{a}_i^{NB} - a_i^{NB}) + F(\bar{a}_j^{NB} - a_j^{NB}) + p\left[\left(\frac{d\bar{a}_i^{NB}}{dp} - \frac{da_i^{NB}}{dp}\right) F'(\bar{a}_i^{NB} - a_i^{NB}) + \left(\frac{d\bar{a}_j^{NB}}{dp} - \frac{da_j^{NB}}{dp}\right) F'(\bar{a}_j^{NB} - a_j^{NB})\right] = \frac{dI}{dp}n, \tag{22}$$

and it implicitly defines the probability of inspection in the *no block* case, p^{NB}.

4.4 EU Accession with the EU Block

In this scenario we assume that the level of abatement for i is decided by the large player and the compliance is full, i.e. $a_i = \bar{a}_i$.

It is not obvious what the objective of the large player should be when acting as the delegate of i, but a natural assumption is that the large player is maximizing the joint payoff between itself and player i. To distinguish this payoff from the payoff of the large player alone, we use the L subscript.

Hence, in the third stage the large player determines the abatement level of player i maximizing the block's payoff, corresponding to the sum of the payofss of the EU and player i:

$$\max_{a_i} U_L = (1+\alpha)B(a_i + a_j) - C(a_i) - t_j + pF(\bar{a}_j - a_j) - I(p). \tag{23}$$

The first-order condition of (23) with respect to a_i is:

$$B'(A) = \frac{C'(a_i)}{1+\alpha}, \tag{24}$$

Comparing this with the level of compliance chosen by player i when acting independently (equation (4)), it is clear that delegation of the decision to the large player brings higher abatement level because the benefit of the latter is now internalized. On the other hand, comparing it with the compliance decision when player i is still under the scrutiny of the large player (equation (8)), it is not clear that forming a block with the large player always induces player i to abate more.

In this stage player j continues to decide her level of compliance unilaterally, and this continues to be given by the analogous form of condition (9):

$$B'(A) = \frac{C'(a_j) - pF'(\bar{a}_j - a_j)}{\beta}, \tag{25}$$

Hence, the equilibrium compliance levels in the third stage of the game with the EU block are given by the system of equations composed of equations (23) and (25), resulting in $a_i^B = a_i^B(\bar{a}_j, p)$ and $a_j^B = a_j^B(\bar{a}_j, p)$.

In the second stage, player j negotiates with a "larger" player than in the *no-block* case. That is because now the large player decides jointly with the i-player, having the joint payoff function given by (23). Intuitively, in this case, we expect that the bargaining position of player j is deteriorated compared to the *no-block* case. In this case, the Nash bargaining problem reads:

$$\max_{t_j,\bar{a}_j}[U_j - U_j^{SQ}]^{\gamma_j}[U_L - U^{SQ}]^{1-\gamma_j} \tag{26}$$

The first order condition with respect to $\bar{a}_j$ is

$$\begin{aligned}\left[\beta B'(\bar{a}_i+\bar{a}_j) - C'(\bar{a}_j) - p\left(1-\frac{da_j^B}{d\bar{a}_j}\right)F'\left(\bar{a}_j - a_j^B(\bar{a}_j)\right)\right]\frac{\gamma_j}{U_j - U_j^{SQ}} + \\ \left[(1+\alpha)B'(\bar{a}_i+\bar{a}_j) + p\left(1-\frac{da_j^B}{d\bar{a}_j}\right)F'\left(\bar{a}_j - a_j^b(\bar{a}_j)\right)\right]\frac{(1-\gamma_j)}{U_L - U^{SQ}} = 0,\end{aligned} \tag{27}$$

and with respect to t_j is:

$$\frac{U_L - U^{SQ}}{U_j - U_j^{SQ}} = \frac{1-\gamma_j}{\gamma_j(1-\lambda_j)}. \tag{28}$$

Substituting (28) in (27), we obtain the negotiated abatement level for player j, $\bar{a}_j$, defined implicitly by the following condition:

$$B'(a_i^B(\bar{a}_j,p)+\bar{a}_j) = \frac{C'(\bar{a}_j) + \lambda_j p\left(1-\frac{da_j^B}{d\bar{a}_j}\right)F'\left(\bar{a}_j - a_j^B(\bar{a}_j,p)\right)}{\beta + (1-\lambda_j)(1+\alpha)}, \tag{29}$$

which gives the negotiated abatement level for the group of countries j as a function of the inspection probability: $\bar{a}_j^B = \bar{a}_j^B(p)$.

We now simplify these FOCs by assuming a linear penalty function, i.e. $F'' = 0$. We know that $\frac{da_j^B}{d\bar{a}_j} = 0$ in this case. This leads to the following FOC for country j:

$$B'(a_i^B(\bar{a}_j,p)+\bar{a}_j) = \frac{C'(\bar{a}_j) + \lambda_j pF'\left(\bar{a}_j - a_j^B(\bar{a}_j,p)\right)}{\beta + (1-\lambda_j)(1+\alpha)}. \tag{30}$$

Comparing this with the condition that gives the negotiated abatement level in the *no-block* case, we can see that, for the same compliance level, the right-hand side of (30) is always lower than the right-hand side of (15). Because the marginal benefit is decreasing, this means that the negotiated abatement level of player j is higher in case the EU acts as the delegate for the two MSs than in the case when the two MSs decide their abatement on their own. This is consistent with our a priori intuition that j's negotiation position deteriorates in the EU-block case. In particular, this is also true if there is no fraud in the funds received from the large player, i.e. $\lambda_j = 0$.

Finally, the transfer to player j is given by:

$$t_j^B(p) = \gamma_j(u_L^B(p) - U^{SQ}) - \frac{1-\gamma_j}{1-\lambda_j}\left(u_j^B(p) - U_j^{SQ}\right), \tag{31}$$

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

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

$$\max_p U_L(a_i^B, a_j^B) = (1+\alpha)B(a_i^B + a_j^B(p)) - C(a_i^B) - t_j(p) + pF(\bar{a}_j(p) - a_j(p)) - I(p) \tag{32}$$

The first order condition is:

$$\begin{aligned} (1+\alpha)\left(\frac{\mathrm{d}a_i^B(p)}{\mathrm{d}p} + \frac{\mathrm{d}a_j^B(p)}{\mathrm{d}p}\right) B'(a_i^B + a_j^B) - C'(a_i^B)\frac{\mathrm{d}a_i^B(p)}{\mathrm{d}p} - \frac{dt_j}{dp} \\ +F(\bar{a}_j^B - a_j^B) + p\left(\frac{d\bar{a}_j^B}{dp} - \frac{\mathrm{d}a_j^B}{\mathrm{d}p}\right) F'(\bar{a}_j^B - a_j^B) = \frac{dI}{dp} \end{aligned} \tag{33}$$

At the very beginning of the game, player i decides to delegate its power of decision to EU or not. This happens to be the case if the payoff of player i in the block equilibrium exceeds that at the no-block equilibrium.

Let $\delta \in [0,1]$ be the share of the payoff allocated to player i from the block's total payoff in the block case. Thus, player i's decision to delegate is given by: $U_i^B = \delta U_L^B > U_i^{NB}$.

This means that if

$$\frac{U_i^{NB}}{U_L^B} < \delta < 1 - \frac{U^{NB}}{U_L^B}, \tag{34}$$

then i agrees to relinquish its power of decision to the EU. However, for the delegation to also be accepted by the large player, i.e. the EU it must also earns more than in the no-block case. This means $U^B = (1-\delta)U_L > U^{NB}$.

5 Example with Quadratic Functions

In order to obtain closed form solutions for the key economic variables, we adopt the following quadratic functional forms for the benefit function:

$$B(a_i + a_j) = b_1(a_i + a_j) - \frac{b_2}{2}(a_i + a_j)^2 \tag{35}$$

and the cost function

$$C(a_k) = \frac{c}{2}a_k^2, \; k = i, \, j, \tag{36}$$

with b_1, b_2, $c > 0$ and $b_1 - b_2(a_i + a_j) > 0$.

Additionally, we assume a linear penalty function

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

with $f > 0$, and a quadratic cost of inspection

$$I(p) = n\frac{g}{2}p^2, n \in \{1, \, 2\}$$

with $g > 0$.

In Appendix A we give the analytical forms for the equilibrium values of the quadratic model, for all scenarios which we only shortly remind below.

The first scenario is the *status quo* given by the Nash equilibrium. In this case, there is no transfer receipt from the EU, nor inspection possibility. Next, in the *no-block* scenario the large player is a Party to the Convention, but the MSs decide their individual abatement levels on their own, i.e. the EU does not form a decision block with the MSs. Lastly, the *block* scenario is identical with the *no-block* one, except that instead of deciding itself the level of abatement, player i, may delegate this decision to the large player. Hence, before the game is played as described in the *no-block* scenario, player i decides whether or not to delegate the abatement decision to the large player. This decision will result from the payoffs comparisons between the *no block* and the *block* scenarios.

For the payoff functions in each scenario, we need to impose conditions such that the example meets the general assumptions introduced in Section 3. The first condition is that $B^{'}(A) > 0$, i.e. $(b_1 - b_2 A) > 0$ for the abatement levels at the status quo, and the second and third stages of the game. We also check that the maximization problem at the first stage of the game is concave $\frac{d^2U}{dp^2} < 0$, and we focus on interior solutions $0 < p < 1$. Next, we ensure the positivity of the abatement levels at the status quo, the second and third stages of the game, and of the transfers at the second stage of the game. Finally, even though theoretically relevant, we exclude the cases of over-compliance as they are not very realistic and, instead, we focus on cases where $f(\bar{a}_k - a_k) > 0$. However, in Appendix A.4 we characterize analytically the over-compliance cases.

5.1 Numerical simulations

We first consider parameter constellations $b_1, b_2, c, f, g, \alpha, \beta, \gamma_i, \gamma_j, \lambda_i, \lambda_j, \delta$ which give our total parameters set. We call it Set 1, consisting of 58320 different combinations. We also consider the subset of Set 1 with parameter constellations that satisfy the above conditions discussed in the previous paragraph. We call this Set 2 and it consists of 25660 elements. Thus, the number of parameter constellations that satisfy the model's assumptions is 44% of total parameters constellations.[11] The following summarizes our preliminary findings in terms of welfare and the levels of abatement and transfers in the three scenarios.

In 494 cases, player i and the EU are better off in terms of individual welfare in the block case than in the no-block case. The reverse holds in 832 cases. Hence, in the majority of cases simulated here, delegation does not take place as it is in neither of the two players' interest to form such a block of power. In the remaining cases player i and the EU have different preferences with respect to the decision institution, i.e., block or no-block.

In Table 1 we separate these cases function of the preferred scenario by the EU together with player i, and we present the averages of the equilibrium variables over the respective number of cases. Thus, in all the 494 cases where delegation takes place, it is interesting to note that player j is also better off in terms of welfare at the block equilibrium than at the no-block equilibrium. This means that countries represented by players i and j would be better off if the EU were part of the Bucharest Convention with delegation of power than without delegation. In the

[11] $|Set2|/|Set1| = 0.44$.

block case, the EU has the power of decision of the abatement level for countries represented by player i. This leads it to choose a more ambitious abatement level for player i (see Table 1). Since the EU block has a larger bargaining power in this case, it negotiates a higher abatement level for player j also. Both facts induce large benefits from total abatement. In the block case, player i is also better off because, even though it now pays larger abatement costs due to the increased abatement burden, it benefits from increased abatement benefits and does not incur penalties for under-compliance. Regarding player j, the result is less expected. It incurs higher abatement costs due to a more stringent abatement burden negotiated with the EU. At the same time, it benefits from larger abatement benefits and it is compensated for its higher abatement effort by larger monetary transfers. These larger abatement benefits and more generous transfers are able to compensate the welfare loss of player j.

Table 1: Average output variables over the set of parameters constellations

	No-Block	**Block**
Number of cases simulated	832	494
Total compliance abatement	3.57	4.83
Total negotiated abatement	4.57	n.a.
Negotiated abatement with i	2.47	n.a.
Negotiated abatement with j	2.10	2.29
Abatement by i	1.97	3.64
Abatement by j	1.60	1.19
Transfer to i	0.67	n.a.
Transfer to j	1.42	3.35
Inspection probability	0.33	0.47
Welfare i	10.57	11.94
Welfare j	9.12	13.51
Welfare EU	22.91	24.64
Social welfare	42.59	50.09
Welfare index relative to full cooperation	0.8831	0.8792
Social welfare staus quo	42.13	43.16
Social welfare full cooperation	48.39	57.00

From Table 1, we make the following observations on the average values of the variables. On average, the index of welfare measured here by the ratio of the total welfare at the underlying game to the total welfare at the full cooperative solution is similar in the block and no-block cases, i.e., 88%. This means that there is a loss of total welfare in both games due to the under-compliance by players i and j relative to the negotiated abatement levels.

In all 1326 cases, we note that the total welfare of the players in the no-block case, as well as in the block case, is larger than that at the status quo. This is expected as now players take into account in part negative emission spillovers thanks to negotiations with the EU. In the following, we investigate the individual welfare levels of different players in order to analyze their position towards the EU membership.

At the no-block equilibrium, in all 832 cases, players i and j are better-off than at the status quo. This means that cooperation with the EU pays off for both groups of countries, regardless of whether they are MSs or not. Thus, this result does not help explaining the resistance of the non-MSs (Russia, Turkey and Ukraine), represented in the model by player j, to the EU accession to the Bucharest Convention. Strikingly, in mere 15 cases out of 832, is the EU better off in the no-block case compared to the status quo. The benefits of the EU from being in the Convention in terms of larger abatement benefits and penalty receipts from under-compliance do not compensate the EU costs of inspection and transfer payments.

At the block equilibrium, in all 494 cases, players i and j improve their welfare relative to that of the status quo. This means that cooperation with the EU is beneficial for both groups of countries. Again, these findings fail to explain the resistance of the non-MSs to the EU accession to the Bucharest Convention. Regarding the EU, the results are mixed. In 237 out of 494 cases, the EU is better off relative to the status quo. This result may be one of the explanations why the EU pushes for the option to be part of the Bucharest Convention. If it detains the power of decision for MSs, then it improves its welfare compared to the current situation represented by the status quo scenario. However, this result does not hold for other parameters constellations, precisely in 257 out of the 494 cases considered. The expressed priority of the EU to join the Convention as a Party could, in these cases, be explained by other arguments such as political or geo-strategic factors.

6 Conclusion

We developed a model that investigates two institutional arrangements through which the EU could influence the abatement decisions of the coastal countries of the Black Sea. We have assumed that when the EU is a Party to the Bucharest Convention, it can negotiate and enforce, via a mechanism of control and verification, certain abatement levels on the coastal countries. The analytical results show that, while the enforcement mechanism indeed increases the abatement levels of the players compared to the status quo, at the strategic level there is leakage both of the negotiated and actual abatement. Nevertheless, the negotiated and actual abatement levels of a given player are strategic complements, such that the higher the negotiated abatement, the higher the compliance of that player. The actual abatement level of each player is influenced by the negotiated level and the inspection probability. However, only the latter decision variable is decided by the EU alone and, as it turns out, the inspection probability can have both a positive and a negative effect on the negotiated targets. This means that high negotiated abatement efforts can be controlled with a high frequency. If, on the other hand, there is no misuse of transfer funds by the recipient countries, then the negotiated level is independent of the probability of inspection.

In order to obtain closed-formed solutions for the key equilibrium variables, we solved the model for the case of quadratic benefit and cost functions. We further resorted to numerical simulations on this quadratic example in order to analyze the welfare of the players and understand their preferences for one institutional arrangement or another. For the accepted parameter constellations, we find that in the majority of the cases the EU and the Member States (MSs) individually prefer that the MSs decide on their own, i.e., the delegation of decision to the EU does not take place. However, the cooperation with the EU is beneficial both from the MSs and non-MSs, regardless of whether the MSs form a block of power with the EU or not. This result creates a puzzle in understanding the motivation of the non-MSs for opposing the EU's accession to the Convention. This puzzle is further enhanced by the fact that the EU is in most cases better off outside of the Convention than as a Party to the Convention. In more than half the cases in which the EU is also the decision-maker of the EU-MSs block, is the EU worse off than in the status quo and would, thus, not prefer to accede to the Convention. The expressed priority of the EU to join the Convention as a Party could, in these cases, be explained by other arguments such as political or geo-strategic factors.

We plan to augment this work with a survey of the current and former stakeholders involved in the pollution problem of the Black sea, including researchers, representatives of the governmental and non-governmental organizations, as well as actors from the local, national and European institutions. The purpose of the survey will be to understand their position with respect to the role of the EU and its membership to the Bucharest Convention. Thus, the survey results will help putting in perspective our results with those declared by the respondents in this survey. A first draft of the results analysis will be available by the time of the conference.

A Appendix: Quadratic Model

A.1 Status Quo: Nash Equilibrium

Conditions (4) give the status-quo (SQ) equilibrium abatement levels:

$$a_i^{SQ} = \frac{\alpha b_1}{b_2(\alpha+\beta)+c} \tag{A.1}$$

$$a_j^{SQ} = \frac{\beta b_1}{b_2(\alpha+\beta)+c}, \tag{A.2}$$

with the resulting payoffs denoted by U_i^{SQ}, U_j^{SQ} and U^{SQ}, for the two players and the large player, respectively.

A.2 "No-Block" Scenario

Conditions (8) and (9) give the equilibrium abatement levels in the last stage of the game:[12]

$$a_i^{NB} = \frac{pf(b_2(\beta-\alpha)+c)+\alpha b_1 c}{c\,(b_2(\alpha+\beta)+c)} \tag{A.3a}$$

$$a_j^{NB} = \frac{pf(b_2(\alpha-\beta)+c)+\beta b_1 c}{c\,(b_2(\alpha+\beta)+c)}, \tag{A.3b}$$

where NB stands for *no-block*.

In the second stage, the large player negotiates separately with each of the small players to determine the abatement targets $\bar{a}_i^{NB}$ and $\bar{a}_j^{NB}$, anticipating the compliance levels from the third stage and taking into account the inspection probability from the first stage. The FOCs given by equations (14) and (15) give the equilibrium negotiated levels:

$$\bar{a}_i^{NB} = \frac{pfb_2(\lambda_j(1+\alpha)-\lambda_i(1+\beta))-cpf\lambda_i+cb_1(\alpha+1-\lambda_i)}{c\,(b_2(\alpha+\beta-\lambda_i-\lambda_j+2)+c)} \tag{A.4a}$$

$$\bar{a}j^{NB} = \frac{pfb_2(\lambda_i(1+\beta)-\lambda_j(1+\alpha))-cpf\lambda_j+cb_1(\beta+1-\lambda_j)}{c\,(b_2(\alpha+\beta-\lambda_i-\lambda_j+2)+c)} \tag{A.4b}$$

[12] The second-order conditions are fulfilled.

The transfer levels are given by equations (18) and (19), which together with the compliance levels (A.3) and the negotiated levels (A.4) give the payoffs U_i^{NB}, U_j^{NB} and U^{NB}, respectively.

In the last stage of the game, the large player determines the inspection probability based on the FOC given by (22).

A.3 "Block" Scenario

Conditions (24) and (25) give the equilibrium abatement levels in the block case:

$$a_i^B = \frac{(1+\alpha)(cb_1 - b_2 pf)}{c\left(b_2(1+\alpha+\beta)+c\right)} \tag{A.5a}$$

$$a_j^B = \frac{cb_1\beta + pf\left(b_2(1+\alpha)+c\right)}{c\left(b_2(1+\alpha+\beta)+c\right)} \tag{A.5b}$$

where B stands for *block*.

In the second stage, the large player negotiates with j. Recall that for player i there is no negotiation and that there is no compliance problem for this player.

$$\bar{a}_j^B = \frac{\left[-\lambda_j c(c+b_2(1+\alpha+\beta)) + b_2^2(1+\alpha)(\beta+(1-\lambda_j)(1+\alpha))\right] pf}{c\left[b_2(1+\alpha+\beta)+c\right]\left[b_2(\beta+(1-\lambda_j)(1+\alpha))+c\right]} + \frac{b_1(\beta+(1-\lambda_j)(1+\alpha))(c+b_2\beta)}{\left[b_2(1+\alpha+\beta)+c\right]\left[b_2(\beta+(1-\lambda_j)(1+\alpha))+c\right]} \tag{A.6}$$

A.4 Characterization of the over-compliance cases

Note that although f is a parameter in our model, whether the fine is applied or not, i.e. $f > 0$ or $f = 0$, is decided in the last stage of the game after the inspection. Consequently, in order to answer the question of over-compliance, we have to reason by backwards induction. Thus, in the case of exact compliance or over-compliance we have that $f = 0$ and this has to be anticipated by all players as early as the negotiation stage. Suppose that for some constellation of parameters we have over-compliance, i.e., $\bar{a}_k < a_k,\ k = i, j$ even if $f > 0$. But in this case, at the inspection stage no fine will be applied, which means that in fact $f = 0$. This should then be anticipated by the players starting with the first stage of the game, which means that compliance and negotiated abatement levels are given by (A.3), (A.4), (A.5) and (A.6), respectively, for $f = 0$.

"No-Block" Scenario

The negotiated abatement levels are:

$$a_i^{NB}|_{f=0} = \frac{\alpha b_1 c}{c\,(b_2(\alpha+\beta)+c)} \tag{A.7a}$$

$$a_j^{NB}|_{f=0} = \frac{\beta b_1 c}{c\,(b_2(\alpha+\beta)+c)}, \tag{A.7b}$$

The compliance levels are:

$$\bar{a}_i^{NB}|_{f=0} = \frac{cb_1(\alpha+1-\lambda_i)}{c\,(b_2(\alpha+\beta-\lambda_i-\lambda_j+2)+c)} \tag{A.8a}$$

$$\bar{a}_j^{NB}|_{f=0} = \frac{cb_1(\beta+1-\lambda_j)}{c\,(b_2(\alpha+\beta-\lambda_i-\lambda_j+2)+c)} \tag{A.8b}$$

Under the condition that $f = 0$, it must also be that there is over-compliance, i.e. $\bar{a}_i^{NB}|_{f=0} \leq a_i^{NB}|_{f=0}$. This condition is equivalent with:

$$\frac{1-\lambda_i}{1-\lambda_j} \leq \frac{\alpha b_2}{\beta b_2 + c}.$$

The analogous condition for player j is:

$$\frac{1-\lambda_j}{1-\lambda_i} \leq \frac{\beta b_2}{\alpha b_2 + c}.$$

Note that in the absence of funds misuse, i.e., $\lambda_i = \lambda_j = 0$, the above conditions are reduced to $(\alpha-\beta)b_2 \geq c$ and $(\beta-\alpha)b_2 \geq c$, for player i and j, respectively. Note that since $\beta < \alpha$, in the case of no misuse of funds, player j can never over-comply with a negotiated abatement target. For player i, condition $(\alpha-\beta)b_2 \geq c$ roughly implies that the benefit of abatement must be sufficiently large compared to the abatement cost, for the strategy of over-compliance to be chosen at the equilibrium.

"Block" Scenario

The reasoning is the same as in the "No Block" case, except that now we investigate the over-compliance for player j only. The negotiated abatement level for player j is:

$$a_j^B|_{f=0} = \frac{cb_1\beta}{c\,(b_2\,(1+\alpha+\beta)+c)} \tag{A.9}$$

The compliance level for player j is:

$$\bar{a}_j^B|_{f=0} = \frac{b_1\,[\beta+(1-\lambda_j)\,(1+\alpha)]\,(c+b_2\beta)}{[b_2\,(1+\alpha+\beta)+c]\,[b_2\,(\beta+(1-\lambda_j)\,(1+\alpha))+c]} \tag{A.10}$$

Then, the over-compliance condition $\bar{a}_j^B|_{f=0} \leq a_j^B|_{f=0}$ is equivalent with

$$c(1-\lambda_j)(1+\alpha) < 0,$$

which is *false* for any constellation of parameters. This means that in the *block* case there can never be over-compliance of player j. Intuitively, this can be interpreted as the result of the large player's negotiation power over j such that the negotiated abatement level is so high it cannot be over-complied. Moreover, A high negotiated abatement level comes with higher monetary transfers from the large player, such that it pays off to pay the under-compliance fine in case of inspection.

References

Ahlvik, L. & Pavlova, Y. (2013), 'A Strategic Analysis of Eutrophication Abatement in the Baltic Sea', *Environmenal and Resource Economics* **56**, 353–378.

Allingham, M. G. & Sandmo, A. (1972), 'Income Tax Evasion: A Theoretical Analysis', *Journal of Public Economics* **1**, 323–338.

Barrett, S. (1994), 'Self-enforcing International Environmental Agreements', *Oxford Economic Papers* **46**, 878–894.

Barrett, S. (2003), *Environment and Statecraft: The Strategy of Environmental Treaty-making*, Oxford University Press Inc., New York.

Battaglini, M. & Harstad, B. (2016), 'Participation and duration of environmental agreements', *Journal of Political Economy* **124**(1), 160–204.

Bayramoglu, B. (2006), 'Transboundary Pollution in the Black Sea: Comparison of Institutional Arrangements', *Environmenal and Resource Economics* **35**, 289–325.

Bayramoglu, B., Finus, M. & Jacques, J.-F. (2018), 'Climate agreements in a mitigation-adaptation game', *Journal of Public Economy* **165**, 101–113.

Becker, G. S. (1968), 'Crime and Punishment: An Economic Approach', *Journal of Political Economy* **76**(2), 169–217.

Black Sea Commission (2002), 'Saving the Black Sea: Official Newsletter of the Black Sea Environmental Program, Issue 7'.
URL: *http://www.blacksea-commission.org/_publ-Newsletter07.asp*

Carraro, C. & Siniscalco, D. (1993), 'Strategies for the international protection of the environment', *Journal of Public Economics* **52**(3), 309–328.

Commission of the European Communities (2007), 'Communication from the Commission to the Council and the European Parliament. Black Sea Synergy – A new regional cooperation initiative"'.
URL: *http://eeas.europa.eu/archives/docs/enp/pdf/pdf/com07_160_en.pdf*

d'Aspremont, C., Jacquemin, A., Gabszewicz, J. J. & Weymark, J. A. (1983), 'On the stability of collusive price leadership', *The Canadian Journal of Economics* **16**(1), 17–25.

El-Sayed, A. & Rubio, S. J. (2014), 'Sharing R&D investments in cleaner technologies to mitigate climate change', *Resource and Energy Economics* **38**, 168–180.

European Environment Agency (2015), 'Black Sea region briefing - The European environment — state and outlook 2015', *European Environment Agency* .
URL: *https://www.eea.europa.eu/soer-2015/countries/black-sea*

Feenstra, T., Kort, P. M. & de Zeeuw, A. (2001), 'Environmental policy instruments in an international duopoly with feedback investment strategies', *Journal of Economic Dynamics and Control* **25**(10), 1665–1687.

Fernandez, L. (2002), 'Trade's Dynamic Solutions to Transboundary Pollution', *Journal of Environmental Economics and Management* **43**(3), 386–411.

Fernandez, L. (2009), 'Wastewater pollution abatement across an international border', *Environmental and Development Economics* **14**(1), 67–88.

Fershtman, C. & Judd, K. L. (1987), 'Equilibrium Incentives in Oligopoly', *The American Economic Review* **77**(5), 927–940.

Finus, M. (2008), 'Game Theoretic Research on the Design of International Environmental Agreements: Insights, Critical Remarks, and Future Challenges', *International Review of Environmental and Resource Economics* **2**(1), 29–67.

Freire-Gibb, L. C., Koss, R., Margonski, P. & Papadopoulou, N. (2014), 'Governance strengths and weaknesses to implement the marine strategy framework directive in european waters', *Marine Policy* **44**, 172–178.

Gren, I.-M. (2001), 'International Versus National Actions Against Aitrogen Pollution of the Baltic Sea', *Environmental and Resource Economics* **20**(1), 41–59.

Gren, I.-M. & Folmer, H. (2003), 'Cooperation with respect to cleaning of an international water body with stochastic environmental damage: the case of the Baltic Sea', *Ecological Economics* **47**(1), 33–42.

Heyes, A. (2000), 'Implementing Environmental Regulation: Enforcement and Compliance', *Journal of Regulatory Economics* **17**(2), 107–129.

Knowler, D. & Barbier, E. B. (2005), 'Managing the Black Sea anchovy fishery with nutrient enrichment and a biological invader', *Marine Resource Economics* **20**(3), 263–285.

Knowler, D., Barbier, E. B. & Strand, I. (2001), 'An Open-Access Model of Fisheries and Nutrient Enrichment in the Black Sea', *Marine Resource Economics* **16**(3), 195–217.

Laukkanen, M. & Huhtala, A. (2008), 'Optimal management of a eutrophied coastal ecosystem: balancing agricultural and municipal abatement measures', *Environmental and Resource Economics* **39**, 139–159.

List, J. A. & Mason, C. F. (2001), 'Optimal Institutional Arrangements for Transboundary Pollutants in a Second-Best World: Evidence from a Differential Game with Asymmetric Players', *Journal of Environmental Economics and Management* **42**(3), 277–296.

Makarenko, I. (2014), 'European Union' Accession to the Bucharest Convention: Legal Aspects and Challenges in Transboundary Context', *Cercetari Marine* (44), 136–146.

Mäler, K.-G. & de Zeeuw, A. (1998), 'The Acid Rain Differential Game', *Environmental and Resource Economics* **12**(2), 167–184.

Roelfsema, H. (2007), 'Strategic delegation of environmental policy making', *Journal of Environmental Economics and Management* **53**, 270–275.

Segendorff, B. (1998), 'Delegation and Threat in Bargaining', *Games and Economic Behavior* **23**, 182–185.

Sengul, M., Gimeno, J. & Dial, J. (2012), 'Strategic Delegation: A Review, Theoretical Integration, and Research Agenda', *Journal of Management* **38**(1), 375–414.

Shi, G.-M., Wang, J.-N., Zhang, B., Zhang, Z. & Zhange, Y.-L. (2016), 'Pollution control costs of a transboundary river basin: Empirical tests of the fairness and stability of cost allocation mechanisms using game theory', *Journal of Environmental Management* **177**, 145–152.

Srinivasan, T. (1973), 'Tax Evasion: A Model', *Journal of Public Economics* **2**, 339–346.

Tavitian, N., Anderson, J., Chiavari, J., Rubel, O., Wittich, A., Mass, A., Carius, A. & Dupont, C. (2008), 'Greening the Black Sea Synergy'.
URL: *https://www.eea.europa.eu/soer-2015/countries/black-sea*

Velikova, V. & Oral, N. (2012), Governance of the Protection of the Black Sea: A Model for Regional Cooperation, *in* V. Lagutov, ed., 'Environmental Security in Watersheds: The Sea of Azov', Springer, chapter 9, pp. 159–171.

Vickers, J. (1985), 'Delegation and the Theory of the Firm', *The Economic Journal* pp. 138–147.