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Stefan Borsky, Paul A. Raschky

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A Spatial Econometric Analysis of Compliance with an International Environmental Agreement on Open Access Resources

Stefan Borsky *   Paul A. Raschky †

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Abstract

This paper provides an empirical analysis of the role of intergovernmental relations on a country's effort to enforce the objectives of an international environmental agreement on an open access resource. Intergovernmental interaction allows signatory countries to observe compliance behavior of other signees and to punish non-compliance by applying bi- and multilateral sanctions. We use a cross-sectional dataset that contains country level information about compliance with the 1995 UN Code of Conduct for Responsible Fisheries. Our identification strategy combines a spatial autoregressive model with spatial autoregressive disturbances and an instrumental variable approach. We find a strong positive effect of other countries' compliance on the individual country's compliance score. These results suggest that repeated interactions among participants might not only play a role in enforcing the obligations of an agreement at the community level but also have an impact at the international level. *(141 words)*

Keywords: International environmental agreements, open access resources, spatial econometrics

JEL classification: C21; F53; Q22;

*Institute of Public Finance, University of Innsbruck, Universitaetsstrasse 15, A-6020 Innsbruck; Email: stefan.borsky@uibk.ac.at. +43 512 507 7174; Fax +43 43 512 507 2788

†Department of Economics, Monash University, 900 Dandenong Rd., Caufield VIC 3145, Australia; Email: paul.raschky@monash.edu. Tel. +61 03 9903 4515; Fax +61 03 9903 1128.

1 Introduction

Global environmental problems require some form of cooperation, like international environmental agreements (IEA), in order to overcome the free-rider problem. However, the voluntary character of many IEAs neither prevents free-riding from non-signatory countries at the participation stage nor free-riding from actual signatory countries at the enforcement stage (e.g. fulfilling the obligations specified in the agreement). The governments of signatory nations have little incentive to enforce the agreements' regulations on their national industries hence the sole ratification of an IEA does not guarantee any success (Finus & Tjøtta 2003). Therefore, it is interesting that we still observe countries participating in the negotiation process and signing an IEA, even if its benefits are nonrival and nonexcludable. Further, why do signatory countries sometimes make an effort to install a mere symbolic treaty in which they agree to obligations which they expect to meet anyway and then even exert positive effort to fulfill (or sometimes overfulfill) these obligations.

Our paper argues, that one possible explanation for this behavior can be found in intergovernmental interaction among the signatory countries. The work by Ostrom (1990) suggests that interaction among individuals and a credible threat of sanctions can help to discourage free-riding and enforce sustainable harvesting rules for open access resources, at least at the community level. On an international level these conditions also exist and are sometimes even more pronounced. Countries do not act independently of each other and can nowadays easily observe whether a signatory nation defects from the agreement or not. In addition, governments have various means to impose sanctions on defectors ranging from diplomatic isolation to trade embargo and the denial of access to an economic or military union. Therefore, the aim of this study is to analyze whether the existence of intergovernmental interaction among the participants and the credible threat of sanctions can help to enforce the obligations of an IEA on open access resources. In particular, we use cross-section data on signatory countries' effort to enforce the obligations of the 1995 UN Code of Conduct for Responsible Fisheries, a voluntary IEA. Our sample contains information from 53 countries, accounting for about 96 percent of the global marine catch, who signed the Code of Conduct. The primary dataset contains evaluation information on each signee's compliance that was compiled in 2005 by an international panel of experts (Pitcher, Kalikoski, Ganapathiraju & Short 2009). We analyze the effect of intergovernmental relations on a country's compliance using a spatial autoregressive model with a spatial autoregressive process in the dependent variable as well as in disturbances and different distance based weighting matrices. The geographical distance between the signatory nations is used as an empirical proxy for the transaction costs of observing other members compliance as well as the frequency of intergovernmental contacts. Due to less stringent normality assumptions as well as computational efficiency we apply a generalized spatial two-stage least square approach as suggested by Kelejian & Prucha (1998). Our results suggest that intergovernmental interaction has a significant impact on a country's level of compliance. Other countries' compliance act as strategic complements and the effect decreases in distance. We also find that a country's quality of governance and its' attitude to sustainable management to have a significant positive effect on compliance score. Decomposing the impact into a direct spatial spillover and an indirect feedback effect suggests that the total effect of a change in an explanatory variable is mainly driven by a direct spatial spillover effect. Furthermore, we find that the spatial spillover effect, i.e. the influence on the the other countries' decision on the level of compliance, is stronger for specific country groups, (e.g. richer countries). This supports the idea of a 'pull' effect on compliance at international level as already proposed by Fredriksson & Millimet (2002) on inter-state level in the U.S.

Our paper extends the findings in the existing empirical literature in three ways: First, to our knowledge, this is the first empirical study to examine compliance behavior under an IEA on open access resources. The existing empirical literature (e.g. Murdoch, Sandler & Vijverberg 2003) that analyses the spatial properties of compliance behavior uses data from (international) environmental agreements on the management of global or local public goods/bads (e.g. emissions). One strand in the literature applies spatial econometric techniques to overcome the problem of migrating emissions on measuring an individual country's reduction effort. Murdoch et al. (2003) point out that the econometric analyses of reduction effort of transboundary pollution is complicated by the fact that individual country's effort is hard to measure as one country's total depositions of a pollutant are the sum of its' own emissions and that of other countries. The application of spatial econometric models and the knowledge of the pollutants' geographic migration patterns helps to reveal each country's emission reduction effort. However, the spatial model cannot be used to isolate the effect on intergovernmental relations on compliance effort. In our case, we directly observe each country's compliance effort and we do not face the problem of transboundary spillovers. We should therefore be able to interpret the coefficient of the spatial lag as the effect of intergovernmental relations. A second strand of spatial econometric studies measures emission reduction effort by comparing differences in the stringency of state (e.g. Fredriksson & Millimet 2002) or national government's environmental regulations (e.g. Eliste & Fredriksson 2004). These papers compare environmental regulations that are not based on an agreement which all states or countries signed and where they actually agreed on some form of cooperative behavior. The absence of such a legal document makes it impossible to define defecting behavior at all and therefore leaves no ground for sanctions.

Second, previous studies solely concentrate on controlling for a spatial autoregressive process while estimating the parameters in their econometric model. The amount of interaction between governments and the ability and credibility to impose sanctions, however, is not homogeneous among countries. Our analysis applies an approach proposed by LeSage & Pace (2009) and decomposes the impact of spatial spillovers into a direct, indirect and total effect. This allows us to differentiate between a spatial spillover and a feedback effect.

Third, both Fredriksson & Millimet (2002) (U.S. states) and Murdoch et al. (2003) (European countries) analyzed decisions regarding environmental agreements of a group of signees that are rather homogeneous in their level of development as well as their ability to enforce the obligations of an environmental agreement. In addition, the participants are located in a relatively confined geographical area, where the criteria of strategic interaction and low transaction costs for observing other participants behavior are more easily fulfilled. We use an IEA that has been signed by countries around the globe providing large variance in levels of development, quality of governance and preference for biodiversity. This gives us the possibility to determine the spatial impact of a change in the level of effort of specific country groups.

The remainder of the paper is structured as follows: Section 2 provides information on 1995 UN Code of Conduct and discusses the theoretical background. Section 3 presents the data and section 4 explains our empirical strategy. Section 5 discusses the results and section 6 concludes.

2 Background and previous literature

During the last decades we have witnessed a tremendous increase in the ratification of international environmental agreements (IEA) on a variety of issues such as ozone depletion, climate change, pollution of oceans and rivers and over-exploitation of numerous species of land- and marine mammals, birds and fish. This development has also triggered the emergence of a vast body of economic literature on this subject[1]. In general these studies deal with two research question. First, are international environmental agreements effective in the provision of the public good compared to the counterfactual outcome. Murdoch & Sandler (1997) evaluated the effects of the 1997 Montreal Protocol on CFC emissions and Murdoch, Sandler & Sargent (1997) compared the effects of the 1985 Helsinki Protocol on Sulphur Emissions and the 1988 Sophia Protocol on NO_x emissions. They conclude that the emission ceilings in the protocols are more in line with non-cooperative Nash behavior rather than cooperative behavior. Finus & Tjøtta (2003) comes to a similar conclusion when analyzing the outcome of the 1994 Oslo protocol on sulphur emissions. This strand of literature mainly suggests that most of the IEAs are powerless and their *raison d'etre* does not

[1] For an excellent survey see for instance Wagner (2001) and Finus (2008)

go beyond a symbolic gesture. Bratberg, Tjøtta & Oines (2005) use a panel of 23 European countries to analyze the effect of the 1988 Sofia Protocol on the participant's NO_x emissions. Applying a difference-in-difference estimator where they consider the non-signatory countries as a control group they estimate a reduction of 2.1% among the signatory countries. They conclude that IEAs can have a positive effect on national environmental policy decisions.

The second strand of research in IEAs deals with the question why countries even participate in international environmental agreements, if they could have the same benefit by free-riding on the behavior of the other countries. Finus & Tjøtta (2003) suggest that governments with re-election concerns try to maximize votes from two groups: First, environmentally concerned voters, who do not have full information about the effect of the IEA, and second, the industry affected by the IEA, which has private information about abatement costs and can influence the political process in a more organized way (e.g. lobby groups). Politicians can gain political support from the former group by simply signing a symbolic IEA and still capture votes from the latter group by agreeing on relatively low obligations. Fredriksson, Neumayer & Ujhelyi (2007) show that governments are more likely to ratify the Kyoto Protocol, if they have strong environmental lobby groups in their country. This argument, however, would not necessarily explain the participation of developing countries in some IEAs, because the fraction of 'green votes' among the electorate is rather low in developing countries and the increase in re-election probability by capturing support from these voters is very small. An alternative argument for cooperation in IEAs is that countries are driven by equity considerations (Lange & Vogt 2003, Lange, Loschel, Vogt & Ziegler 2010). This strand of literature argues that negotiating politicians are not only driven by the absolute payoff from a proposal for their own country but also by the relative payoff compared to the other participating countries. Preference for equity seems to describe well countries behavior at the negotiation and participation level, but do not automatically describe the variance in enforcing the actual obligations. A further explanation is based on the potential effect of repeated intergovernmental relations and resulting bi- or multilateral sanctions if a country defects from the agreement. This argument basically builds on the ideas of Ostrom (1990). Burton (2003) incorporated these ideas in a theoretical model on community enforcement of voluntary effort restrictions on fisheries, while Bratberg et al. (2005) suggest that the enforcement of a treaty's obligations via strategic interaction of the signees could also be a valid explanation for IEAs' existence. Fredriksson & Millimet (2002) account for interaction between governments on environmental policymaking at U.S. state level by including the abatement levels of neighboring states as explanatory variables. Their results imply that U.S. states with already more stringent environmental policies have a positive "pull" effect on their neighbor's decision on abatement levels. Murdoch et al. (2003) provide a spatial probit analysis of 25 European countries to sign the Helsinki protocol as well as their decision on the level of enforcement. They use the amount of spillins and targeted spillins of all other signatory countries to identify a countries strategic response. They find that spillins increase cooperation at the participation stage but induce free-riding at the enforcement stage.

2.1 Intergovernmental relationship and compliance behavior

While the standard economic literature on IEAs (Barrett 1994) takes the negotiating government as exogenously given, we assume that politicians who are responsible for negotiating and enforcing an IEA are driven by re-election concerns. Persson & Tabellini (1992) were among the first who analyzed the effects of strategic voting on the outcome of multilateral agreements in a theoretical framework. Buchholz, Haupt & Peters (2005) extended this analysis to IEAs[2]. The government will increase its' re-election probability if the electoral benefits of compliance exceed its domestic and international costs. Let us first have a closer look at the potential benefits from signing and enforcing an IEA on sustainable fishery. In the case of IEAs on fisheries it is reasonable to assume that the re-election probability mainly

[2]Eckert (2003) examined the effect of constitutional rules on participation and enforcement of an IEA in a two-country model where each country consists of two federal sub-regions. Depending on the delegation of powers between the federal and the regional governments each country can have a strategic advantage in the negotiation game.

depends on two groups of voters in society, general citizens and the fishery industry. The general citizens have some 'green' preferences for sustainable management of international fish stocks. One might think of this as the value attached to the sole existence of a certain fish species, either the one that is directly subject to the IEA (e.g. tuna) or indirectly in the case of larger predators (e.g. dolphins). However, obtaining information about the optimal set of rules to ensure a sustainable level of harvest is costly for each citizen and therefore the average citizen is badly informed. The politician can capture support from these 'uninformed green voters' twice: First by simply signing a mere symbolic IEA which is very visible. Second, if the industry complies or even over-complies, the voters might attribute this success to the (unobservable) enforcement effort of the politician.

Regarding the domestic costs of signing and enforcing the IEA, a first subset of costs comprises of loss in voter's utility through the IEA. The support for IEAs on certain pollutants (e.g. CO_2) is in general rather low because the IEA's obligations infer costs on the average citizen as well. The situation is different for IEAs on biodiversity or fisheries, which mainly affect a narrow industry. In most of today's economies the fishery industry has become an increasingly unimportant sector when it comes to employment[3] and contribution to GDP[4]. However, this does not necessarily suggest that the government does not pay attention to the demands from this group. The government might even pay relatively more attention to the preferences expressed via the industry's lobbying groups (Persson 1998) as compared to the general electorate. The fishery industry has private information about its compliance costs (Finus & Tjøtta 2003) and the government can therefore capture votes from both the green voters and the fishery industry by signing an international environmental agreement with loose obligations. The government simply negotiates for low compliance goals at the signatory level and/or keeps the level of enforcement low. Another factor influencing the costs of compliance for the domestic industries is driven by the heterogeneity of fishing ca-

[3] According to FAO (1999) the average percentage of fishers among the economically active population in agriculture in high-sea fishing countries was around 4.8% in 1990.

[4] The average percentage of fishery exports per GDP among high-sea fishing countries was around 0.8% in 1995 (FAO 1999).

pacity between industries in different countries. Dayton-Johnson & Bardhan (2002) and Burton (2003) provide community-level models of fishery that allow for heterogeneity in fishing capacity among the different players.

A second subset of costs is related to the enforcement of the IEA. In many countries the fishery industry is dispersed over a number of locations and the central government delegates the control task related to the IEA to bureaucratic agencies or regional governments. Installing and maintaining a bureaucratic apparatus that controls the compliance requires public funds that could be used to provide public goods elsewhere. These direct costs of enforcement depend on the country's level of institutional quality.

Our main interest is on the impact of international costs related to the IEA. These costs emerge basically from not signing or not complying to the IEA. They could be defined directly in the agreement or could be a result from resulting sanctions in strategic interactions among the signatory governments. At community level (e.g. a small fisher town), strategic interaction among participants of an agreement make the threat of sanctions more credible, thus increasing each participant's reduction effort and decreasing the incentive to free-ride(e.g. Ostrom 1990, Burton 2003). Ostrom (1990) outlined a set of 5 broad characteristics that need to be met in order to have a stable agreement: 1) Members support the rules of the agreement and effective monitoring. 2) Outsiders can be excluded. 3) Members or communities have repeated communication and dense social networks. 4) The harvesting (and compliance) effort of the other members is observable. 5) Moderate rates of change in the stock of resources and the level of harvesting technology. So far, the literature (e.g. Dietz, Ostrom & Stern 2003) suggests that there are only a few settings in the world that fulfill all 5 conditions. Most of these cases can be found in situations where a common property resource is shared by a community in narrowly defined geographic area.

Common property resources where sustainable management requires some form of international cooperation between a number of countries have so far been considered not to fulfill the necessary conditions for an Ostrom-type governance of the commons. Maybe this argument does not hold for all IEAs. Let us first have a look at how the institutional framework created by the 1995 UN Code of Conduct for Responsible Fisheries actually performs vis-a-vis these 5 conditions. We basically go through the conditions one by one and examine how these characteristics apply to the Code of Conduct : 1) The participating nations agreed to the set of rules by signing the agreement. Although the Code of Conduct is voluntary, there is some legal document were signees clearly indicated their approval. If one member country defects from the agreement there is at least the possibility for other members to refer to the legal document. 2) The Code of Conduct was signed by 53 countries that account for 96 % of the global marine catch. Although it is not possible to exclude the fishing nations responsible for the remaining 4 % of the global catch, we are confident that new entrants play a negligible role. 3) Although the fishing industries from different nations do not engage in frequent face-to-face communication, the official representatives of the signatory countries do. They meet permanently in international boards (e.g. UN general assembly meetings, WTO meetings) and engage in a wide number of negotiations (e.g. EU and NATO enlargement). Hence, there is strategic interaction among the participant countries at least at the diplomatic level. In addition, there are bi- and multilateral tools that make the threat of sanctions, in case a member country defects, very plausible. For example, EU-member countries use the veto-threat to block participation aspirations of some of its neighbouring countries such as Turkey and Croatia. 4) It is assumed that signatory nations do neither have information about the others compliance effort and it could be hard to identify players that defect. However, this is not the case in high-seas fishing. Nowadays, fishing nations actually have very good information about other countries fishing practices and harvesting effort, both legal and illegal. 5) It is probably not reasonable to assume a moderate change of technology over this 10-year period.

Although this was just a back-of-the-envelope comparison, its purpose was to illustrate that there is some ground for supporting the idea that on international level, strategic interaction among governments could have an effect on country's compliance behavior in the context of an IEA. Among Ostrom's characteristics the extent of knowledge about other members' behavior (characteristic 4) and the frequency of interaction among countries (characteristic 3) define the probability that defection and under-compliance will be revealed as well as the likelihood of becoming subject of bi- or multilateral sanctions. The key assumption of this paper is that these characteristics, and therefore the likelihood of a sanction, are inversely related with the distance between two countries. It is easier for Australia to observe fishing behaviour of Japanese vessels in a high-sea fishing zone in the Indian Ocean than it is to observe Nigerian vessels in a high-sea fishing zone in the Atlantic. The amount of interactions between official representatives of two countries also decreases in distance. Although most countries have representatives in multinational boards and organizations there are other multinational institutions that are composed of only countries within a specific region of the world (e.g. EU, MERCOSUR, ASEA, African Union). Based on this discussion we argue that, all else equal, the compliance behavior of one country is positively related to the compliance behaviour of other countries and this effect is decreasing in distance.

2.2 The 1995 UN Code of Conduct for Responsible Fisheries

The Code of Conduct for Responsible Fisheries had its origin in the 19^{th} session of the FAO's Committee on Fisheries (COFI) in 1991. Related to the discussion on pelagic driftnet fishing, the COFI pointed out the importance of the FAO to promote more sustainable fishing gear and techniques. This idea was further developed and formalized at the 1992 International Conference on Responsible Fishing in Cancun. The participating nations signed a declaration that called upon the FAO to draft a Code of Conduct for Responsible Fishing. In October 1995, the Code of Conduct for Responsible Fisheries was adopted unanimously by the members of the Food and Agriculture Organization of the United Nations. The general objective of the Code of Conduct is to promote sustainable development and harvesting of world fisheries through responsible management (Hosch, Ferraro & Failler 2011). The code consists of 12 articles, where the first 6 articles mainly describe the legal framework of the

Code and articles 7 to 12 are of more technical nature and define the Code's objectives. Most importantly, the Code of Conduct is non-binding and the principles and standards provided in the legal text are only of voluntary nature. In 2005 after 10 years of Code of Conduct 53 countries, accounting for 96 percent of the global marine catch, have been evaluated according to their compliance with the code's suggestions for sustainable fisheries (Pitcher et al. 2009). The results have been quiet disillusioning. Not one of those countries evaluated reach an overall compliance score of more than 60 percent. The authors suggest that the lack of compliance is mainly due to the voluntary character of this international environmental agreement.

A second assessment by Hosch et al. (2011) using 9 case studies comes to a similar conclusion: Although a lot of signatory countries have implemented laws that reflect the objective of the Code of Conduct, actual change in fishing practices is hardly observed. They suggest that a lack of political will and administrative inertia are among the reasons, why the positive influence of the Code on domestic laws is not translated into real action.

3 Data

We compiled our dataset from a number of sources. Our main variable of interest, compliance with the Code of Conduct, is taken from the study of Pitcher et al. (2009). They evaluated the performance of all 53 signatory countries[5] using a set of 44 different score variables. Each score variable ranges from 0 to 10, with higher scores indicating better compliance. The definition of the score variables is directly drawn from the clauses of the Code. Pitcher et al. (2009) used a great number of separate sources including: national legislation, international treaties (www.searoundus.org), country synopses from FAO, reports to FAO and NGOs, webpages of national fisheries agencies, NGO websites as well as information of published work and fisheries experts to derive the compliance score for each country. To ensure consistency,

[5]Given that these 53 countries account for 96 percent of the global marine catch, we are confident that sample selection bias plays a negligible role.

a formal scoring protocol was employed.

The 44 score variables can be divided into 6 different subgroups. These 6 subgroups can then be broadly categorized into *behavioral* and *intentional* indicators. The former set of performance indicators summarizes measures, which requires real action. It contains mainly indicators that are quantifiable and have an immediate effect on fishing stocks. The first subgroup in this category summarizes a nation's compliance with respect to regulations on stocks, fleets and gear, $Regulations$. This subgroup examines for example whether by-catch of non-target species is minimized or excess fleet capacity has been actually reduced. It also investigates whether fishing methods are harmful and whether the country invests some real effort to rebuilt depleted stocks. The second behavioral subgroup evaluates the country's monitoring, control and surveillance system, MCS. It inspects the effectiveness to monitor implemented rules and estimates the extend of illegal fishing in the country's fishing area. The last subgroup is the least tangible criteria in the behavioral category and deals with social and economic questions, $Socio - Econ$. It evaluates how the government manages conflicts among different fishing sectors, how the needs of indigenous people and local fishing communities are met.

In contrast, intentional measures contain a number of performance indicators that could be considered less tangible and implementation and maintenance of some of these indicators does not necessarily require large effort and funds from the government. These subgroups have a more symbolic character and evaluate a country's good intentions. Management objective, $Objectives$, contains a set of scores for the country's plans to meet the requirements of the Code of Conduct. Does the management plan aim to restore depleted stocks or does it consider human impacts (e.g. pollution) on the fishery habitat? The second intentional subgroup evaluates the procedures how the plan is actually implemented, $Framework$. For example, does the management plan contain long-term objectives? It verifies whether the country applies timely and appropriate statistics to gather information about the progress in implementing the goals set out in the management plan. The final set of questions accounts for precautionary intentions, *Precautionary*. It basically collects information about contingency plans, the role of uncertainty about fish stocks in setting the management objectives and the design of the internal review process.

Although both set of indicators are important to evaluate a country's compliance to the code of conduct, we expect a stronger strategic intergovernmental interaction in the indicators that measure actual behavior. For example, a fishing country that has updated its fleet to meet the criteria of minimizing by-catch wants its competitors in the same fishing area also to apply to this criterion. Vessels from the complying nation observe the equipment of other fishing nation's vessels. If these other vessels use less-sustainable (but more effective) fishing methods, the fishermen from the complying nation are disadvantaged. Hence, fulfilling this requirement of the code of conduct is costly and has a direct effect on the fishermen's competitiveness. The complying country's government can collect reports about the other country's under-compliance and initiate sanctions. In comparison, the complying nation is less interested whether the other fishing nation has developed plans and compiled a set of management objectives to meet the requirements of the code of conduct. An additional argument for the preference for the behavioral measures is that compliance to the intentional measures does not necessarily result in real action (Hosch et al. 2011).

We use similar empirical proxies as McWhinnie (2009) for technological capability, harvesting costs and government's ability to enforce compliance. As data on fishery specific technology is not available, we use the country's gross domestic product, GDP, to measure a country's technical capability. Data on GDP per capita (Purchasing Power Parity) stems from the Word Development Indicators (WDI 2007) and is varying between \$ 776 and \$ 32145 with a mean of \$ 11899 . To capture harvesting costs we use the average distance from a country to the FAO zones it is operating, $COST$. We use a GIS-shapefile with coordinates of ports in each country and identified the closest port to each FAO area. We then calculated the great circle distance from this port to the center of a FAO zone and repeated this step for each FAO zone the country is fishing in. These distances were weighted by the fish capture of the country in the respective FAO zone. In our sample Bangladesh, Senegal and Japan are on average high distance fishing countries, whereas the Philippines, Ireland and Peru are fishing the main part of their capture in waters close to their home port. As a measure of the government's ability to enforce compliance, we use a standard measure for quality of governance based on PRS group data, GOV. This is a composite indicator that combines, among others, information about governmental stability, bureaucratic quality and corruption. We further add a dummy variable EU that accounts for countries, who are subject to the EU's common fishery policy. Furthermore, the country's cost of compliance is influenced by the degree of competition in the FAO area, $COMPET$. To capture this characteristic we use data on fishing behavior from the FAO fishery statistics. First we construct $n \times m$ matrices for the 17 FAO major fishing areas, where each country pair get 1 if they are competitors in the same fishing area. Then we sum up the competitors in the fishing area and take the average over all fishing areas of the country's number on competitors. This allows us to measure the average strength of competition a country faces in the fishing areas. Ecuador, Peru and Mexico are the countries with the lowest degree of competition with 6 competitors on average. The Netherlands, Ireland and Sweden face an average of 16 competitors in a fishing zone, which makes them to the countries with the highest degree of competition. Our measure on environmental performance, BIO, stems from the Yale Environmental Performance Index (Emerson, Esty, Levy, Kim, Mara, de Sherbinin, Srebotnjak & Jaiteh 2010), which provides a composite index from six subareas. We have chosen one of the subareas - biodiversity - for our measure of environmental performance of a country for the following reasons. First, there are concerns of high collinearity of the overall environmental performance index with the GDP of a country. This stems from the fact that 50 % of the index is based on environmental health variables, like water sanitation. Second, the biodiversity index is based on following variables: the national extend of protected areas, a measure of the degree to which the country's wildest areas are protected, the timber harvest rate and the oversubscription of water resources. In our opinion this subgroup captures the countries attitude to sustainable management and use of natural resources best. In our sample Yemen is the country with the lowest score of 13.7 and New Zealand has the highest score with 73.5 points. To measure the size of the fishing industry in relation to the country size, we use data on the export value of fish from the FAO Fisheries Statistics divided by GDP per capita of that country, $EXPORT$. The size of the fishing industry allows us to capture two country characteristics. First, it is a measure for the openness of a country to the world market. Second, it captures the potential of the industry to lobby against costly adaptations to more sustainable fishing measures. Bigger industries will easier get attention by the government and politicians will avoid implementing policies, which could affect many voters negatively in the short run. According to our sample Egypt has the smallest share of fishing exports on GDP per capita with 0.0017% and New Zealand is the country with the highest share of fishing exports on GDP per capita with around 18%. Table 1 reports descriptive statistics of the variables we use in our regressions.

4 Empirical Implementation

To determine the influence of intergovernmental relationship on the country's level of effort, as discussed in section 2.2, we base our empirical strategy on a spillover model of strategic interaction (Brueckner 2003). In this framework a country decides on the level of compliance c_i, but the country is simultaneously affected by the level of compliance chosen elsewhere, which indicates the spillover effect.[6] This leads to the following objective function for country i:

$$V(c_i, c_{-i}; X_i) \tag{1}$$

[6] Following Autant-Bernard & LeSage (2010) in static cross-sectional models of spatial interaction, where observations reflect a steady state equilibrium outcome, the countries' simultaneous decision on the level of compliance can be interpreted as representing a sequence that would occur over time during movement to the next steady state equilibrium.

where c_{-i} is a vector of the chosen level of compliance c by the other countries and X_i is a vector of intracountry characteristics of country i, which determine preferences for the i's level of c. Country i chooses the level of c_i to maximize equation (1). Due to the fact that this depends on both, c_{-i} and X_i, the solution can be written as :

$$c_i = R(c_{-i}; X_i) \tag{2}$$

where function R represents a reaction function, which indicates country's i response to the compliance behavior of the other countries. The position of the reaction function depends on the intracountry characteristics X of country i. Following our previous discussion on intergovernmental relationship we expect the sign of the reaction function's slope to be positive, which indicates that the decisions on the level of compliance is a strategic complement. For our empirical analysis of the effect of intergovernmental relations on compliance we can write the econometric function with the following general form

$$c_i = \rho W_n c_j + X_i \beta + \epsilon_i \tag{3}$$

where c_i is a $i \times 1$ vector of the dependent variable, X_i is the $n \times k$ matrix of control variables, β is the corresponding $k \times 1$ vector of regression parameters and ϵ_i is an error term. W_n is a $n \times n$ spatial weighting matrix, with elements ω_{ij}, which represents nonnegative weights that typically capture the pattern of interaction between country i and country j. The scalar autoregressive parameter ρ reflects the strength of interaction between country i and country j. Given our assumption that each country's level of effort is public knowledge to the other countries and that the decision of the own and the other countries decision are determined simultaneously, equation (3) cannot be consistently estimated using OLS since the spatial lag $\sum_{j=1}^{J} \omega_{ij} c_j$ is endogenous and correlated with the error term ϵ_i (Ord 1975, Anselin 1988). Estimation is further complicated due to another form of interdependence that arises in spillover models of strategic interaction. It is a often assumed that ϵ_i includes omitted variables that are spatially dependent. In this case governments will share some unobserved, regional characteristics, that are correlated with the effort to comply with code's suggestions. Spatial correlation in the error term can make OLS estimates inefficient (Anselin 1988).

$$\epsilon_i = \lambda M_n \epsilon_i + v_i \tag{4}$$

where M_n is a $n \times n$ spatial weighting matrix, which is assumed to be the same as W_n in equation (3). λ is again a scalar autoregressive parameter, which reflects the strength of interaction between country i and country j and v_i is a well-behaved $n \times 1$ vector of error terms. To deal with the problem of a spatial autoregressive process in the dependent as well as in the error term we apply an instrumental variable (IV) type approach for cross-sectional models as suggested by Kelejian & Robinson (1993) and Kelejian & Prucha (1998), proceeding in three steps.[7] In the first step equation (3) is estimated using a two-stage least squares estimator (2SLS), where the matrix of exogenous instruments H is a subset of linear combinations of, X^*, the other countries' characteristics and, W_n, a weight matrix. In this step the spatial autoregressive process in the error term is ignored:

$$H = \left(X, W_n X, W_n^2 X\right) \tag{5}$$

Using $Z = (W_n c_i, X)$ we can define the consistent, but not efficient, 2SLS estimator for ρ and β as

$$\left(\tilde{\rho}, \tilde{\beta}'\right)' = \left(Z' P_H Z\right)^{-1} \left(Z' P_H c_i\right) \tag{6}$$

where $P_H = H \left(H'H\right)^{-1} H'$. Although the first step deals with the simultaneity problem of the compliance decision, one still needs to account for the spatial autocorrelation in the error

[7] An alternative approach to estimate these models requires the use of maximum likelihood (ML) estimators. But recent literature has shown that the IV estimator approach is computationally simpler, has similar performance in small samples to ML and has no distributional assumption (Kelejian, Prucha & Yuzefovich 2004).

term. Therefore, in the second step, we derive the residuals from the first step to estimate λ and the variance σ_v^2 of the i.i.d. error term in equation (4) by general moments' method as proposed in Kelejian & Prucha (1999). This estimation method leads to a consistent estimation of $\tilde{\lambda}$. In the last step we apply a Cochrane-Orcutt transformation to the model to account for spatial correlation and reestimate equation (6) by a 2SLS procedure. By this transformation we get $c^*\left(\tilde{\lambda}\right) = c - \tilde{\lambda}W_n c$, $X^*\left(\tilde{\lambda}\right) = X - \tilde{\lambda}W_n X$ and $Z^*\left(\tilde{\lambda}\right) = Z\left(\tilde{\lambda}\right) - \tilde{\lambda}W_n Z$, which leads finally to the consistent and asymptotical normal generalized spatial two-stage least squares estimator (GS2SLS) for ρ and β

$$\left(\hat{\rho}, \hat{\beta}'\right) = \left(\hat{Z}^*\left(\tilde{\lambda}\right)'\hat{Z}^*\left(\tilde{\lambda}\right)\right)^{-1}\hat{Z}^*\left(\tilde{\lambda}\right)'c^*\left(\tilde{\lambda}\right) \tag{7}$$

Following our econometric strategy we estimate the following function for each of the 6 different compliance indicators:

$$\begin{aligned} COMPL_i = \rho\sum_{j=1}^{J}\omega_{ij}COMPL_j + \beta_1 GDP_i + \beta_2 COST_i + \beta_3 GOV_i \\ \beta_4 EU_i + \beta_5 COMPET_i + \beta_6 BIO_i + \beta_7 EXPORT_i + \epsilon_i \end{aligned} \tag{8}$$

$COMPL_i$ is the compliance score of country i, ω_{ij} is a spatial weight assigned to country j by country i, $COMPL_j$ is the compliance behavior of country j and ρ is the corresponding parameter of interest. Strategic interaction between governments requires ρ to be statistically significant, where a nonzero coefficient implies that the country's level of compliance is a function of the effort made by other countries'. According to our hypothesis, we expect ρ to have a positive sign. The null hypothesis is that there is no strategic interaction effect between the governments, which suggests that the decision on the level of compliance is made independently. A country's decision on the level of effort is, of course, not only the outcome of strategic interaction between governments. Rather, in absence of interaction effects, each government is influenced by a set of intracountry factors, which form the basis for choices of the level of compliance effort. We expect the country's with higher technological capabilities to achieve better compliance score. Mean distance to the fishing areas, $COST$, and mean competition among the FAO zones, $COMP$, are expected to be negatively correlated with compliance behavior. GOV should depict a positive sing. A country's effort to preserve biodiversity, BIO, is used to capture the attitude of a country's citizens towards environmental issues. The coefficient is expected to have a positive sign. In contrast, we expect that a strong fishing industry, $EXPORT$, has a negative influence on the compliance score. Following Gray & Hatchard (2003) and Daw & Gray (2005) the EU common fishery policy (CFP) can be seen as a political success but an environmental failure. Due to the strict top-down structure of the CFP and a choice of fishery management tools giving the wrong incentives the CFP leads to an alarming state of many fish stocks within the European waters. Therefore we expect the sign of EU to be negative.

To capture the spatial relationship, a variety of spatial weight matrices are constructed. The distance information was generated by using longitude and latitude information (taken from the CEPII database) of each country's most populated cities. First, weight matrices of spatial interdependence are calculated using the inverse distances between the most populated city of each country pair in our sample, *Distance*. The distances are calculated according to the great circle formula. Choosing the most populated cities and not the capitals of a country for our distance calculation allows us to capture the distance between the economic centers of the countries. Second, we use the squared inverse distance between the most populated cities of each country pair to determine the off diagonal elements of the matrices ,$Distance^2$. Using the squared inverse distance simply assigns closer countries a stronger weight than more remote ones. For the third weight matrix, $Near^2$, we apply a nearest neighbor concept, where countries are defined to be neighbors if the distance between their most populated cities is less than 3150 kilometers, which is the minimum distance from the most remote country in our sample to his nearest neighbor. This cut-off point has been taken in order to avoid a so called 'island states' effect in weight matrices(Anselin 1988).

In our sample countries have on average 8 neighbors, where Senegal has with 19 neighbors the highest amount of neighbors whereas Canada, Australia, Netherlands, Philippines and Egypt have just one neighbor. The off diagonal elements of the weight matrices have been determined in the following way. If countries are outside those distance bands, they are assigned a value of 0 else the off diagonal elements of the matrices are defined by the squared inverse distance. We have chosen to use the squared distance, because it allows us to give nearer countries a stronger weight.All matrices are row standardized.

5 Results

5.1 Regression Results

We first estimated equation (8) for each of the three behavioral compliance indicators, *regulations, MCS* and *Socio-Econ.* Table 2 presents the spatial estimates for the determinants of the compliance behavioral indicators using squared inverse distance weighting matrix, which gives closer countries more weight than the inverse distance weighting matrix [8]. The sign of the spatial lag ρ is positive and significant at the 1%-level in 2 out of 3 cases. This suggests that a country's compliance behavior is positively influenced by the compliance of other signatory countries. Our empirical proxies for harvesting technology ($\ln(GDP)$) and costs ($COST$) do not appear to have a significant impact on enforcement behavior. These results are in line with McWhinnie (2009). Countries with a higher quality of institutions have significantly better compliance scores. As expecteded, members of the European Union (EU) sharing the EU CFP have on average a lower compliance score. This is in line with a broad scientific literature (e.g. Gray & Hatchard 2003, Daw & Gray 2005), that the CFP does not support or give the right incentives for a sustainable use of the fish resource in the common waters. The remaining indicators for cost of compliance, average competition

[8] For robustness checks we have defined spatial dependency using the other weighting matrices described above, but our estimates do not change significantly.

in the FAO area ($COMPET$), a country's effort to protect biodiversity (BIO) and the importance of the fishing industry ($EXPORT$) do not depict a significant coefficient. The choice of instruments passes the Hansen-J test for over-identification and the second stage estimates yield a sufficiently large R^2 between 0.5 and 0.8 depending on the compliance indicator. In contrast to the previous compliance indicators, we do not find a significant spatial relationship among country's compliance behavior captured by our weakest behavioral indicator, $Socio - Econ$. Compliance to Socio-economic objectives seems to be only driven by the quality of governance and is inversely related with the effort to protect biodiversity.

In addition to the enforcement of behavioral objectives, we repeated our exercise for the intentional indicators as well. Table 3 presents a summary of this analysis by presenting the estimates for the three intentional indicators, *objectives*, $framework$ and *precaution* using the squared inverse distance weight matrix. Strategic interaction plays a significant role on enforcement effort regarding *precaution* (at the 5%-level) but not in the case of $framework$ and *objectives*. Once again, quality of governance is the main driver of compliance behavior. In contrast to the behavioral compliance scores, effort to protect biodiversity is significantly positively correlated with compliance in all three areas.

5.2 Determining the impact of spatial spillovers

The dependence structure in a spatial regression model allows us to retrieve more detailed information about the interaction effects (LeSage & Pace 2009). Consider for example the effect of institutional quality, GOV. An improvement in this variable in country i will have a direct effect on the compliance of country i as well as an indirect effect on the compliance of all other countries due to the spatial dependence [9]. Following LeSage & Pace (2009) the magnitude of the spatial spillover will depend upon the position of the countries in space, the degree of connectivity among them, which is determined by the spatial weight matrix W, the

[9] Due to this interdependencies the derivative of y_i with respect to x_{jk} will be potentially non-zero and is determined by the spatial multiplier $n^{-1}\iota'(I - \rho W)^{-1}\iota$ and the direct impact β_k, where n is the number of observations and ι is a $n \times 1$ vector of ones. The spatial multiplier captures the magnitude and distribution of the spatial spillovers in the system. For a more detailed discussion see (e.g. Anselin 2003).

parameter ρ, which represents the strength of spatial dependence in our variable of interest and the parameter β. The total effect of a change in the explanatory variable consists of three components: the direct effect, due to the change in the explanatory variable; the indirect spatial spillover effects, which indicates the impact from the change in country i to the other countries; and a direct spatial spillover effect, which can be interpreted as a feedback loop. This feedback loop captures the effect that arises from a change of the explanatory variable in country i on the dependent variable in country j and the change in country j also affects the dependent variable in country i. Since the impact of changes in the explanatory variables differs over all observations, LeSage & Pace (2009) suggest using scalar summary measures of these impacts. Table 4 presents the scalar summary measures for a simultaneous marginal increase in the k^{th} explanatory variable accounting for spatial spillover effects and divided into direct, indirect and total effects. In comparison to our previous estimates, as presented in Table 2 and Table 3, we see a significant increase in the impact of changes of the explanatory variables on a country's compliance effort. Depending on the different compliance indicators the magnitude of the increase in impact differs between 1.620 $\times\beta_k$ and 6.113 $\times\beta_k$, which represents the size of the spatial multiplier. This suggests that ignoring the spatial spillover effects while estimating the factors determining the level of compliance will lead to biased estimates that underestimate the impact of the variables by a factor of 1.6 to 6.1, respectively. Focusing on the components of the total effect gives us an interesting insight on the importance of the spatial spillovers in our model of strategic interaction. For the compliance indicators that require real action, *regulations* and *monitoring*, we observe that the magnitude of the impact is mainly driven by spatial spillover effects cumulated over all regions in the sample. Compared to the direct effects the behavior of the other countries influences the decision on the level of compliance by country i in the extent of 60% to 79% respectively. Whereas in the case of the intentional indicator *precautions* the decision on the level of effort is just affected by the behavior of the countries in the extend of 36%. These results support our argument that the complying country is less interested whether other fishing nations have developed plans and compiled a set of management objectives to meet the requirements of the code of conduct than in measures that require real actions.

Since Table 4 represents cumulative parameter estimates for a simultaneous marginal increase in the k^{th} explanatory variable, we are not able to examine the dissemination of the impact of a change in compliance effort of a particular country or group of countries in space. Therefore, following Egger, Larch, Pfaffermayr & Walde (2008), we exogenously change a single country's explanatory variable by a standardized amount $\Delta\left(\hat{\beta}X_k\right) = 1$ and holding all other variables constant. This allows us to focus on the spatial spillover effect of a change in compliance effort, where the magnitude of the effect depends on the position of the country in space, the degree of connectivity among the countries and the strength of spatial dependence. Following our discussion on the intergovernmental relationship and compliance behavior we expect that strategic interactions between governments make a threat of sanctions for non-compliance more credible. Furthermore, we assume that the potential to sanction non-compliance is not equally distributed among the participating countries, but rather depend on specific characteristics, like the level of economic development. Therefore, we calculate the direct, indirect and total effect of a standardized change in an explanatory variable for country groups that differ in their level of economic development (Table 5). First, let us look at the case, where the quartile with the highest economic development changes their compliance behavior, measured by *regulations*, by one unit. With 3.866 the total effect of such a change will be far above the average effect and will be mainly driven by the spatial spillover effect. Now, let us consider the case where the quartile with the lowest economic endowment changes their compliance behavior by unity. With 2.500 the total effect is below the average effect and just about 2/3 of the total effect of the highest quartile. By looking on the distribution of the total effect into the direct and indirect effect we see that the difference of the impact of a standardized change on compliance behavior of the highest compared to the lowest quartile is mainly due to a change in the spatial spillover effect. This effect can be strongly observed in both behavioral compliance indicators, *regulations* and *monitoring*. In our intentional compliance indicator, *precautions*, the impact of the spatial spillover compared to the total effect as well as the difference between the highest and lowest quartile is not that strong, which again supports our argument that countries are more interested in real action than in good intentions. In a further step, we increase the group size to analyze the behavior of this effect in more detail. Therefore, we divided the sample in two equally sized groups, a group with relatively richer and a group with relatively poorer economies. Focusing on the total effect we are able to observe an interesting effect. Whereas the total effect of the group of poorer nations is nearly constant, the total effect of the group of richer nations changes significantly. This effect stays robust for both, the behavioral and intentional indicators. Following these results we are further interested, if we are able to find an optimal group size, where the total effect of a unitary change in compliance behavior is the biggest. Table 6 presents our calculations of the cumulative total effect for a standardized change in a country's explanatory variable. Starting with the country, with the highest level of economic development and than adding the second richest country and so on, our results suggests that the optimal group size with the highest total effect, consists of the nine richest countries. These findings stay robust over all three indicators measuring compliance effort, the two behavioral, *regulations* and *monitoring* and the intentional indicator, *precautions*, whereas the influence of the group size is the weakest in our intentional indicator. This means that the magnitude of the total effect is more equally distributed than compared to our behavioral indicators.

6 Conclusion

So far, strategic interactions among participants have only been considered to be useful in enforcing the objectives of an agreement in the context of small communities. This paper suggests that some international environmental agreements and existing intergovernmental relations fulfill, to a certain extent, the criteria of an Ostrom-type mechanism to manage open access resources. Modern technology allows countries to observe other signatory countries' compliance behavior and repeated intergovernmental relationships make the threat of sanctions in the case of non-compliance credible. We use cross-section information on country-level compliance to the 1995 UN Code of Conduct for Responsible Fisheries to identify the drivers of the participating countries' effort levels. To estimate the effect of strategic interaction on one country's compliance behavior we use the spatial lag of the other countries' compliance behavior and apply a generalized spatial two-stage least square approach as suggested by Kelejian & Prucha (1998). We find strong support that a country's enforcement effort of objectives that require real action is positively related to the other signees' level of compliance. The relationship is rather weak for objectives that are more symbolic. We also find evidence that quality of governance, EU membership as well as a country's effort to protect biodiversity have an impact on compliance behavior. Furthermore, we find that the spatial spillover effect, i.e. the influence on the the other countries' decision on the level of compliance, is stronger for specific country groups, e.g. richer countries. This supports the idea of a pull effect on compliance on the international level.

Our results suggest that intergovernmental relationships have an impact on a country's effort to enforce the objectives of an IEA on open access resources. However, the low levels of overall compliance to the agreement indicate that strategic interaction on international level is not a sufficient constraint to ensure the sustainable management of an open access resource.

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Table 1: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Regulations	49	2.548	1.735	0.143	7.286
MCS	49	4.459	1.717	1.333	9.167
Socio − Econ	49	3.772	1.902	0.333	8.000
Objectives	49	4.392	1.809	1.333	8.222
Framework	49	4.977	2.006	0.857	7.857
Precaution	49	3.771	2.287	0.667	7.667
GDP	49	9341.047	10976.470	241.984	35959.340
COST	49	717.200	1668.991	0.876	8960.758
GOV	49	0.660	0.209	0.311	0.996
EU	49	0.245	0.434	0.000	1.000
COMPET	49	11.407	2.518	6.000	16.000
BIO	49	49.353	15.656	13.700	73.500
EXPORT	49	0.008	0.026	$1.77e{-5}$	0.183

Table 2: Determinants of Compliance on Behavioral Objectives

Weight matrix:	*Regulations*	*Monitoring*	*Socio − Econ*
ρ	0.644***	0.836***	−0.232
	(0.164)	(0.307)	(0.385)
ln(GDP)	0.006	−0.059	0.043
	(0.035)	(0.043)	(0.038)
$COST$	0.005	0.055	0.072
	(0.049)	(0.084)	(0.148)
GOV	5.445***	7.484***	5.645**
	(1.643)	(2.395)	(2.147)
EU	−1.260**	−1.496***	−0.356
	(0.514)	(0.556)	(0.520)
$COMPET$	−0.005	0.042	−0.069
	(0.076)	(0.076)	(0.090)
BIO	0.005	−0.001	0.030***
	(0.008)	(0.011)	(0.011)
$EXPORT$	2.809	3.497	−3.881
	(3.587)	(5.413)	(4.484)
Hansen J-Statistic	0.262	0.731	0.832
Anderson-Rubin Wald test	0.000	0.006	0.108
1^{st} stage F-Test	0.000	0.004	0.000
R^2	0.785	0.600	0.540

Notes: Weight Matrix: *Squared Inverse Distance*. 49 observations. Robust standard errors in parenthesis. ***, **, * indicate significance at the 1, 5 and 10%-level, respectively.

Table 3: Determinants of Compliance on Intentional Objectives

Weight matrix:	*Precaution*	*Framework*	*Objectives*
ρ	0.383**	0.125	0.407
	(0.158)	(0.310)	(0.311)
$\ln(GDP)$	0.015	0.011	−0.010
	(0.022)	(0.025)	(0.027)
$COST$	0.032	−0.055	−0.007
	(0.053)	(0.047)	(0.070)
GOV	7.232***	6.638***	6.529***
	(1.348)	(1.761)	(1.760)
EU	0.207	−0.344	−0.621
	(0.462)	(0.479)	(0.463)
$COMPET$	−0.050	−0.054	−0.073
	(0.072)	(0.081)	(0.076)
BIO	0.016**	0.038***	0.021**
	(0.007)	(0.010)	(0.010)
$EXPORT$	−0.971	0.223	1.185
	(3.377)	(3.183)	(3.050)
Hansen J-Statistic	0.265	0.648	0.369
Anderson-Rubin Wald test	0.016	0.259	0.000
1^{st} stage F-Test	0.000	0.000	0.000
R^2	0.778	0.692	0.670

Notes: Weight Matrix: *Squared Inverse Distance*. 49 observations. Robust standard errors in parenthesis. ***, **, * indicate significance at the 1, 5 and 10%-level, respectively.

Table 4: Quantifying Direct, Indirect and Total Effects

		Cumulative Average Effects		
		Regulations	**Monitoring**	**Precaution**
ln(GDP)				
	Direct	0.006	-0.075	0.015
	Indirect Spatial	0.009	-0.284	0.009
	Total	0.016	-0.359	0.024
COST				
	Direct	0.005	0.070	0.033
	Indirect Spatial	0.008	0.264	0.019
	Total	0.014	0.334	0.052
GOV				
	Direct	6.067	9.560	7.462
	Indirect Spatial	9.250	36.189	4.258
	Total	15.317	45.749	11.720
EU				
	Direct	-1.404	-1.911	0.213
	Indirect Spatial	-2.140	-7.233	0.122
	Total	-3.544	-9.144	0.335
COMPET				
	Direct	0.005	0.053	-0.051
	Indirect Spatial	0.008	0.201	-0.029
	Total	0.014	0.255	-0.080
BIO				
	Direct	0.006	-0.002	0.017
	Indirect Spatial	0.009	-0.007	0.010
	Total	0.015	0.009	0.026
EXPORT				
	Direct	3.129	4.467	-1.001
	Indirect Spatial	4.771	16.910	-0.571
	Total	7.900	21.376	-1.573

Notes: Weight Matrix: *Squared Inverse Distance*. 49 observations. Spatial Multiplier: Regulations (2.813); Monitoring (6.113); Precautions (1.620).

Table 5: Spatial effects of a standardized change in an explanatory variable

	Countrygroup	Direct	Indirect	Total
Regulations				
	Average	0.114	1.699	2.813
	Highest Quartile	0.168	2.698	3.866
	Lowest Quartile	0.120	1.380	2.500
	1^{st} & 2^{nd} Quartile	0.133	2.023	3.155
	3^{st} & 4^{nd} Quartile	0.096	1.388	2.484
Monitoring				
	Average	0.277	4.835	6.113
	Highest Quartile	0.449	9.030	10.479
	Lowest Quartile	0.275	3.386	4.662
	1^{st} & 2^{nd} Quartile	0.334	6.228	7.562
	3^{st} & 4^{nd} Quartile	0.223	3.498	4.721
Precaution				
	Average	0.032	0.589	1.620
	Highest Quartile	0.044	0.830	1.874
	Lowest Quartile	0.034	0.512	1.546
	1^{st} & 2^{nd} Quartile	0.036	0.667	1.703
	3^{st} & 4^{nd} Quartile	0.027	0.514	1.541

Notes: Weight Matrix: *Squared Inverse Distance*. Rank Variable: GDP per capita (constant 2000). Spatial Multiplier: Regulations (2.813); Monitoring (6.113); Precautions (1.620).

Table 6: Cumulative spatial effects of a standardized change in an explanatory variable

Rank	*Regulat.*	*Monitor.*	*Precaution*	*Rank*	*Regulat.*	*Monitor.*	*Precaution*	*Rank*	*Regulat.*	*Monitor.*	*Precaution*
49	2.034	3.395	1.387	32	3.398	8.589	1.760	15	2.935	6.665	1.650
48	2.850	6.489	1.608	31	3.352	8.357	1.753	14	2.910	6.576	1.643
47	2.875	6.241	1.636	30	3.256	8.038	1.724	13	2.914	6.583	1.645
46	2.587	5.441	1.540	29	3.214	7.840	1.715	12	2.903	6.528	1.642
45	2.896	6.598	1.625	28	3.232	7.893	1.721	11	2.884	6.453	1.637
44	3.109	7.348	1.687	27	3.211	7.767	1.719	10	2.859	6.370	1.630
43	3.331	8.240	1.745	26	3.155	7.563	1.703	9	2.836	6.290	1.623
42	3.749	9.979	1.846	25	3.184	7.655	1.712	8	2.837	6.272	1.624
41	4.033	11.179	1.914	24	3.133	7.471	1.698	7	2.811	6.189	1.616
40	3.921	10.632	1.891	23	3.108	7.373	1.691	6	2.816	6.182	1.619
39	3.950	10.770	1.898	22	3.108	7.322	1.695	5	2.789	6.101	1.610
38	3.866	10.479	1.874	21	3.076	7.188	1.688	4	2.804	6.132	1.615
37	3.692	9.838	1.828	20	3.058	7.127	1.682	3	2.805	6.116	1.617
36	3.604	9.506	1.804	19	3.029	7.009	1.676	2	2.799	6.085	1.616
35	3.574	9.350	1.799	18	2.997	6.897	1.666	1	2.813	6.113	1.620
34	3.446	8.890	1.764	17	2.968	6.798	1.658				
33	3.433	8.795	1.764	16	2.942	6.693	1.652				

Notes: Weight Matrix: *Squared Inverse Distance.* Total Cumulative effects. Spatial Multiplier: Regulations (2.813); Monitoring (6.113); Precaution (1.620).

Appendix: Description and Sources of Variables

Table 7: List of countries

Angola	Latvia
Argentina	Morocco
Australia	Mexico
Bangladesh	Malaysia
Brazil	Namibia
Canada	Nigeria
Chile	Netherlands
China	Norway
Germany	New Zealand
Denmark	Pakistan
Ecuador	Peru
Egypt	Philippines
Spain	Poland
France	Portugal
United Kingdom	Russian Federation
Ghana	Senegal
Indonesia	Sweden
India	Thailand
Ireland	Turkey
Iran	Ukraine
Iceland	United States
Italy	Vietnam
Japan	Yemen
Korea. Rep.	South Africa
Sri Lanka	

Table 8: Variable description and sources

Variable	**Description**	**Source**
Regulations	Measures the degree of compliance on regulation on stocks, fleets and gear	Pitcher et al. (2009)
MCS	Measures the degree of compliance on effectiveness of monitoring, control & surveillance. Also measures the extent of illegal fishing	Pitcher et al. (2009)
$Socio - Econ$	Measures the government's ability to manage conflict among different fishing sectors and how needs of minorities are met	Pitcher et al. (2009)
Objectives	Evaluates the government's plans and strategies to meet the objective of the Code of Conduct.	Pitcher et al. (2009)
Framework	Evaluates the government's procedures of implementing the plans and strategies.	Pitcher et al. (2009)
Precaution	Measures the degree of precautionary principles and the among of contingency plans applied.	Pitcher et al. (2009)
$\ln(GDP)$	Natural log of Gross domestic product per capita in 2000, in constant Dollars (PPP)	World Bank (2008) WDI
COST	Minimum great circle distance between port and center of a fishing zone weighted by the amount a country is fishing in that zone	Authors' calculation FAO (2008)
GOV	ICRG indicator of Quality of Government. Higher values indicate higher quality of government.	PRS Group (2007)
EU	Dummy variable = 1 if country is member of the European Union and 0 otherwise.	Authors' calculation
COMPET	Average degree of competition in FAO areas in which the country is fishing.	Authors' calculation
BIO	Biodiversity & Habitat indicator from Yale Environmental Performance Index. Measures the degree at which a country achieves a target of protecting terrestrial biome, critical habitats and manages marine protected areas.	Emerson et al. (2010)
EXPORT	Export value of fish divided by GDP	Authors' calculation World Bank (2008) and FAO (2008)

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A spatial econometric analysis of compliance with an international environmental agreement on open access resources

Abstract
This paper provides an empirical analysis of the role of intergovernmental relations on a country's effort to enforce the objectives of an international environmental agreement on an open access resource. Intergovernmental interaction allows signatory countries to observe compliance behavior of other signees and to punish non-compliance by applying bi- and multilateral sanctions. We use a cross-sectional dataset that contains country level information about compliance with the 1995 UN Code of Conduct for Responsible Fisheries. Our identification strategy combines a spatial autoregressive model with spatial autoregressive disturbances and an instrumental variable approach. We find a strong positive effect of other countries' compliance on the individual country's compliance score. These results suggest that repeated interactions among participants might not only play a role in enforcing the obligations of an agreement at the community level but also have an impact at the international level.

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