Do Regional Environmental Agreements Have Any Effect on Water Quality?

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This empirical research analyzes the link between environmental agreements and the level of pollution in transnational waterbodies. It attempts to capture if environmental agreements have any impact on the actual level of pollution observed in transnational waterbodies and what are the determinants of the existence of such agreements. To answer these two questions, this paper matches the Global Environmental Monitoring System Water Database (which covers the period 1979-1990 and has the broadest coverage of waterbodies worldwide), with other variables such as the countries' geographical locations, the existence of environmental agreements, the countries' populations and their GDP's. The econometric results indicate that the more specific the water treaties, the greater is their impact on water quality in international rivers. On the other side, a poor state of the water only seems to lead to signing of general treaties on frontier waters.

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I. Introduction

In recent years, environmental issues have become a prominent theme of public debate at the international level. Two major world meetings have been convened (in 1972 at Stockholm and in 1992 at Rio de Janeiro), and the large number of countries attending them made clear the level of interest in the international dimensions of environmental problems. Regional trade agreements such as NAFTA and the EC contain special clauses with respect to the environment. There are also other nearly 1,000 international legal instruments which have environmental provisions (Weiss, Szasz, and Magraw, 1992).

However, as nations continue to negotiate new agreements at an increasing rate, it seems crucial to ask whether existing ones have been effective in improving the state of the natural resources concerned, and also about what led those treaties to be signed. The main question this empirical study tries to answer is whether environmental agreements have had any impact on the actual level of pollution observed in international watercourses. It also provides some conjectures about the determinants of those treaties.

The empirical data available to address these issues is relatively scarce. There are specific treaties on pollution, which have their own monitoring programs (e.g., the Baltic Sea, the Rhine, or the European Environmental Monitoring Programme). However, the source with the broadest world-wide coverage is the Global Environmental Monitoring System (GEMS), which includes both air and water pollution for the period 1979-1990. This paper focuses mainly on water pollution information from that database because water treaties are very numerous and involve a whole range of different countries. While two regional agreements do exist for air pollution, and have been signed predominantly by developed nations[1].

To study the relationship between international water treaties and the quality of the resource, the GEMS/Water database is the most useful. It contains information on natural factors affecting water quality, such as temperature of the water and discharge, and can be merged with variables describing the human impact on the environment (such as GDP and population density). The strongest results are obtained for Dissolved Oxygen, which is the only direct indicator of water quality, and the one with the most observations and number of countries represented. Different types of water treaties appear to have a positive impact on the quality of the water, and the more precise the treaty, the higher seems to be its effect. On the other hand, the state of the resource does not seem to play a very significant role in terms of inducing countries to sign environmental agreements, except perhaps for general treaties on frontier waters.

The paper is organised in the following way. Part II contains a brief review of the literature on environmental agreements relevant to this research. Part III presents the data used for the analysis. Part IV covers the underlying model and the econometric analysis performed, and Part V summarises the main results and conclusions.

II. Review of the Literature

International environmental agreements have been studied in both the legal and the

[1] Those are the Convention on Long-range Transboundary Pollution (1979) which includes basically Europe and North America, and the Agreement on Air Quality between the United States and Canada (1990).

economic literature. International environmental law writings typically address the characteristics of these agreements, and to a lesser degree the extent of compliance with their provisions. Birnie and Boyle (1992) describe the specifics of environmental agreements of various kinds. There are also several publications which list the treaties which have been signed: UNEP (1993); Weiss, Szasz, and Magraw (1992); or Ruster, Simma & Bocks (1983) and Ruster & Simma (1990), which report all environmental agreements signed since 1754. In addition, Sand (1992) surveys the most important environmental treaties and analyses their effectiveness, as do Weiss and Jacobson (1995).

Various authors in environmental economics have developed theoretical arguments about international agreements. Examples include Mäler's (1990) analysis of the net benefit of a European Agreement for Acid Rain and Tahvonen, Kaitala and Pohjola's (1993) study on the sustainability and cost-effectiveness of a treaty to reduce sulphur emissions between Finland and the former Soviet Union. The literature on the impact of environmental regulation on productivity, international competitiveness, and growth has also some point of contact with this paper. From that literature, of the most immediate relevance to this paper is Grossman and Krueger (1995), which deals with the link between economic growth and the state of the environment in a cross section of countries. The database utilised here is the same, but the focus is on the relation between international treaties and the state of the environment. To the author's knowledge, nothing has been written to quantify the impact of environmental agreements on the quality of the resource to which those treaties refer.

III. The Data

The actual data used for this paper are annual, and consist of a sample of the most often reported pollutants in the GEMS/Water database[2]. These are the same data utilised by Grossman and Krueger (1995). Dummies for environmental treaties are assembled from various legal sources. The water data are augmented with some additional variables which are natural determinants of water quality, and variables that reflect human factors, and thus, may have some impact on treaty signing and on the state of the resource.

A. Water Quality Indicators

There are several different indicators for water quality, and the most important ones are included in the sample. Of the 11 indicators reported, one (Dissolved Oxygen) is a direct measure of quality. The remaining ten are measures of pollution, and can be divided into four groups [3]:

i. Oxygen Balance. The oxygenation of water is achieved naturally through turbulence but some substances deplete that oxygen. There are two measures of oxygen balance: Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The former refers to the natural demand for oxygen by bacteria or other living organisms in

[2] The Global Environmental Monitoring System (GEMS) was established after the 1972 Stockholm Conference on the Environment in order to coordinate the gathering of worldwide environmental data. The program has compiled a database on a large number of water pollutants for the period 1979-1990, for 423 monitoring stations (287 for rivers, 60 for lakes, and 76 for groundwater) in 58 countries around the world.

[3] This classification corresponds to UNEP (1995).

freshwater, and the latter reflects the use of oxygen by chemicals present in the water.

ii. Microbial Pollution. Freshwater bodies are polluted by fecal discharges, which contain bacteria. Two usual measures for that kind of pollution are Fecal Coliforms and Total Coliforms (which also includes non-human sources). These are the most variable of pollution measurements.

iii. Nutrients. Nutrients are present in agricultural fertilisers, animal wastes and municipal sewage. The specific nutrient reported in the sample is Nitrogen in its oxidised form (Nitrate).

iv. Heavy metals. Heavy metals are discharged into the water by economic activities such as agriculture or mining. The metals reported in the sample are Lead, Cadmium, Arsenic, Mercury, and Nickel.

Table 1: Main statistics for each indicator in the international stations

	Rivers and Lakes			
	Mean	**Std.Dev.**	**#Obs.**	**# Countries**
DissO_2	8.023	2.683	599	29
BOD	8.062	30.555	488	26
COD	65.708	175.48	302	17
Fecal Coliforms	22,313	155,479	457	20
Total Coliforms	53,884	123,730	169	11
Arsenic	0.0042	0.0041	108	8
Nickel	0.0095	0.013	190	5
Mercury	0.260	0.608	236	13
Cadmium	0.0011	0.072	251	13
Lead	0.0046	0.478	225	10
Nitrate	2.503	5.537	332	20

Note: All the means are in mg/l, except Mercury (μg/l) and Fecal and Total Coliform (No/100 ml). The means and standard deviations are calculated for all observations in international monitoring stations for all the years reported for each indicator.

The panel is unbalanced. The number of stations reporting differs across countries, as do the number of years reported per station. The original sample contains information on international (and national) rivers, lakes, and groundwater. However, only rivers and lakes are used in this research because few international environmental agreements deal directly with groundwater. In addition, only international stations are considered, in order to focus on capturing the effect of treaties among countries on border resources by comparison with conditions at those stations, which are also international but are not under the influence of any agreement. All the relevant monitoring stations are listed in Appendix A, organised according to the basin to which they belong[4]. The main watersheds, together with many other (less important) freshwaters, are represented in the data, so that there does not seem to be much of a problem of sample bias. Table 1 summarises the main statistics (mean and standard deviation) and the number of observations for each indicator[5]. The table also specifies the total number of countries involved in each case.

[4] The raw data did not contain a distinction between national and international stations. Hence, Cartopedia (1996) was used to locate the location of the stations whose exact coordinates were contained in the data.

[5] Some of the zeros reported in the data were eliminated because they seemed to correspond to situations in which countries had missing data, since they immediately followed very high values which could not have being lowered in such a short time.

There is no consensus on benchmark water-quality criteria to use in judging whether there is “too much” pollution. In general, those target levels of water quality differ according to the water use (it is different for drinking than for recreation) since they reflect basically the possible health consequences of pollution. In addition, some countries have slightly different standards than others. The data in Table 2 reflect both these aspects of existing water-quality criteria.

Table.2: Water quality criteria according to different countries

	Canada	*Norway*	*Netherlands*
DissO_2	5 to 9.5		
BOD			
COD			
Fecal Coliform			
Total Coliform		5 to 500	
Arsenic	0.05 to 5		0.005 to 0.01
Nickel	0.025 to 1	0.01 to 0.1	0.009 to 0.01
Mercury	0.0001 to 0.003		0.00002 to 0.00003
Cadmium	0.0002 to 0.02	0.0002 to 0.001	0.00005 to 0.0002
Lead	0.001 to 0.1	0.001 to 0.015	0.004 to 0.025
Nitrate	0.06 to 10		

Note: This table was constructed from information of ECE (1993a.). All measures are in mg/l, except Fecal and Coliform which are in No./100 ml.

As can be seen in table 1, the indicators with the largest number of observations (and represented countries) are Dissolved Oxygen, BOD, Fecal Coliforms and Nitrate. Dissolved Oxygen is the only direct measure of water quality, while the other three are measures of oxygen balance, microbial pollution and nutrients. The econometric analysis performed in part IV deals with these four indicators, attempting to find the relationship between their values and the presence or absence of international water treaties.

B. International Treaties on Freshwaters

Historically, the earliest international environmental agreements on water tended to be related to the creation of scientific water bodies concerned with the exploration of the seas or “remote” regions like Antarctica. The next type of treaties to emerge was concerned with the management of collective resources, mostly fisheries. Finally, by the end of 1960s various international regimes emerged to control pollution into waterbodies either from shipping or from dumping of waste. Those latter treaties constitute the focus of this research.

There are several listings of international environmental agreements, but obtaining a comparable indication of the existence and the type of agreement requires a common source. The most complete reference on environmental agreements is Ruster, Simma and Bocks (1983) and Ruster and Simma (1990), because they report all freshwater agreements signed since 1754. That source is the one used here. It is supplemented with information from the references named in section II and a rather comprehensive document by the Economic Commission for Europe (1993b).

Many stations in rivers or lakes are international but do not have any treaty. However, when there is an agreement, it can be of different types. Some treaties relate to all freshwater resources which form the borders among neighbour countries (as an example, consider one of the oldest treaties of this kind: Convention concerning the Boundary Waters between the United States and Canada, 1909) . Others are regional treaties, linked to the name of a particular water resource (e.g., the Treaty on the River Plate Basin, 1969, or the Act regarding Navigation and Economic Co-operation between the States of the Niger Basin, 1963). Their coverage can include topics such as navigation, fisheries, water withdrawal or pollution. Some treaties deal with particular pollutant (e.g., Convention on the Protection of the Rhine Against Pollution by Chlorides, 1976).

Some agreements are mere declarations of intention, others are more precise. When countries agree on a particular instrument to regulate their behaviour, in general it has to do with the emissions standards they commit themselves to attain. The most usual framework is that countries agree to reduce their emissions by a certain percentage in a stated time frame. Those targets are sometimes different across pollutants (e.g., in the Rhine Action Plan there are two categories of substances with different reduction requirements)[6].

In this research, agreements are classified in three broad categories (and dummy variables are constructed for each one of them):

i. Treaties on frontier waters (Treaty 1) signed among the countries to define certain principles on the waterbeds that are on their frontiers. Agreements can be on navigation, use of the water, limits, etc.

ii. Treaties concerning a specific water resource (Treaty 2) signed by all countries crossed by a certain river or bordering some lake. They can be on fisheries, on the construction of a dam, on navigation, etc.

iii. Treaties on pollution of a specific water resource signed to combat its pollution (Treaty 3). These treaties refer to general pollution of a particular river or lake, or to a specific pollutant.

Related to treaties, another variable incorporated into the database is the relative position of each country with respect to the watershed. This factor is captured through dummy variables which specify if the country is located upstream or downstream along a river, or if that river (or lake) constitutes a border. The sources for that information are the Standard Encyclopaedia of the World's Rivers and Lakes (1965), and Cartopedia (1996).

C. Natural Determinants of Water Quality

If there were no human activity, water quality would be determined by natural factors like surface runoff, water discharge or temperature. Surface runoff is influenced by latitude, elevation and location on continents. Water discharge is linked to the size of the waterbody and local rainfall patterns. Water temperature depends on local climate, but also on other factors such as upstream influences (e.g., snow melt).

The database includes several variables describing the location of the monitoring station: its exact Latitude, the Octant, and the Region to which it belongs (Africa, America, Middle East, Europe, Southeast Asia, and West Pacific Region). To complement the information on latitude provided by the database, a variable for the Southern Hemisphere is added because the water temperature and climate are typically warmer for the same latitude in the Northern Hemisphere than in the Southern one.

The sample used in this paper also contains some information on discharges, elevation of the monitoring station, depth of the water and temperature. But this information

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[6]Some technology requirements by type of activity are another usual requirement in that type of treaties (as they are in domestic water regulation).

is rather incomplete since only one-third of the overall sample contains information for discharge, while two-thirds of the stations report temperature[7]. To complete the records on temperature, reference regressions are run for the set of observations which do have temperature data reported. Then, the coefficients of these regressions are used to predict the value of temperature for the observations for which temperature is not reported, but discharge, elevation and depth of the water at the stations are available. Several alternative auxiliary regressions have to be run because for some stations none of these variables exist in the database, while for others, only one or two of them are available. Appendix B shows these auxiliary regressions and their results.

Another factor that may influence the water quality values observed in the data is the Measurement Method used by each station. Eight of the eleven parameters are measured using one of two different laboratory methods. Dummy variables are created to take this measurement factor into account.

D. Human Factors Affecting Water Quality and Treaty Signing

Human influences on water come from direct pollution discharges, waste disposal, agricultural runoff, atmospheric deposition or accidental releases. Hence, water quality is closely linked to factors such as economic development and population density. While all participants in the GEMS Program provide other documentation on their country, only natural factors related to each specific station are included in the database. Hence, other variables have to be appended to the data.

It would be ideal to possess information on industrial and agricultural production, or population density, for the regions which are close to the watershed. The scarcity of comparable data makes this impossible, so the study is restricted to country-level indicators. The smaller the countries and the larger the water bodies, the lower will be the distortion induced by using these proxies. In Europe, data at the level of a country gives a good idea of the effect of human activities on the environment, because very often the rivers in question cross entire (small) countries. However, this does not occur with many large American and Asian countries. The series on real GDP per capita (Laspeyres index, international prices base 1985) are taken from Summers and Heston (1991,1996), where data are expressed using a common set of prices and currency for every country in the sample[8]. The same source is used for Population. The Area of each country (to obtain Population Density) is taken from Cartopedia (1996).

Even if it seems that water treaties are signed in developed and underdeveloped countries, it may be the case that GDP plays some role at the moment of signing a treaty (e.g., governments of more developed countries are more conscious of the environmental problems, and also have a better bureaucracy to negotiate). Other variables as Openness of the economy (measured as exports plus imports over nominal GDP, from Summers and Heston's database) are incorporated to the analysis because they are thought to have some impact on the tendency of a country to sign treaties. The same is true for political factors such as whether the government has been elected and whether it is a parliamentary system[9].

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[7] Of the 2466 observations in the whole sample (including groundwater), 2055 include temperature and 1048 include discharge.

[8] The actual source used in this research is a data set available on line at http://www.harvard.edu/pwt56.html

[9] These variables were constructed following the approach used by Banks (1973).

IV. Methodological Issues and Results Obtained[10]

The underlying model to estimate using these data consists basically of two equations. One of them explains water quality and the other explains treaties. One way of thinking about these equations is to view them as a supply and a demand for environmental agreements. On one side, more treaties "supplied" should lead to a finding of less pollution, while when a water resource is very polluted there is a greater "demand" for treaties as a remedy. In the latter case, treaties is the dependent (dummy) variable while in the former water quality is the dependent variable. One must estimate a system of two equations to model a pair of jointly dependent variables.

The effect of treaties ($Trat_{it}^{j}$) on water quality (Wq^{j}_{it}) can be specified as an equation to explain water quality which includes natural factors affecting water quality, and human factors, one of which may be that countries sign treaties among themselves to protect their common resource:

$$Wq_{it}^{j} = \alpha_1 \cdot n_{it} + \alpha_2 \cdot h_{it} + \alpha_3 \cdot Trat_{it}^{j} + \tau_{it},$$

where j indicates the type of treaty, i signals the monitoring station, t is a time index, and τ is the error term (assumed to have mean zero and finite variance[11]). Human causes of water quality degradation (GDP per capita, Density, Geographic position with respect to the resource -Up, Down, Frontier-) are represented by h_{it}. Factors related to natural causes or measurement methods (being a Lake or a river, Temperature of the water, and Method[12]) plus a Trend effect are denoted by n_{it}.

Similarly, the extent to which the degree of water pollution influences treaties' signing can also be conceptualised through an equation of the following form, this time with the presence or absence of a treaty as the dependent variable:

$$Trat_{it}^{j} = \phi_1 \cdot h'_{it} + \phi_2 \cdot n'_{it} + \phi_3 \cdot Wq_{it} + \xi_{it} \ ,$$

where j denotes the type of treaty, i is a monitoring station index, t is a time index, ξ is the error term with mean zero and finite variance. The human variables used as regressors are (h'_{it}) are GDP, the geographic location with respect to the resource (being upstream or downstream), and the political variables (openness, parliament, elections). A dummy for lakes (n'_{it}) is added to control for any difference among the type of resource to which the treaties refer.

The main problem to be faced in the task of assessing the effectiveness of regional agreements on water quality and the need for those agreements in highly polluted watersheds stems from the simultaneity of both treaties and pollution. It may be that international treaties

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[10] All the econometric results are obtained using LIMDEP, Version 6.0 (1992). The computer program written for this paper is contained in Appendix C.

[11] This assumption is made to concentrate on endogeneity that is the principal problem for this issue, rather than worry about autocorrelation or heterocedasticity.

[12] Latitude is not included here with the idea that it is closely correlated to temperature. Consequently, it does not add much to the regression.

have a positive impact on water quality, but at the same time, higher levels of pollution are what determine their existence. The same is true with respect to the reference sample (those observations for which there is no treaty). In such a case, the equations to estimate would have endogenous right hand-side variables. A simple Ordinary Least Squares (OLS) estimation would yield coefficients that are biased and inconsistent because the standard assumption of independence among the regressors and the error term is violated. Unobserved factors affecting pollution may also affect treaty signing. On the other hand, unobserved effects that influence treaty signing are likely to increase both the probability of their occurrence and the resulting pollution amounts.

The correct process in the presence of this endogeneity is a two-step procedure (Heckman, 1978 or Dubin and McFadden, 1984). It involves regressing the suspected endogenous variable against exogenous variables, and using those results as an instrument in the original regression. However, the first step here is different for each one of the two equations given the different nature of the independent variable. In the reduced form regression to create instruments for treaties, the first step consists of a Probit estimation because the dependent variable is discrete, while in the reduced form regression to create instruments for water quality, the first step is an OLS estimation.

In addition, each one of the two structural regressions must be identifiable in the sense that there must be some factors that affect pollution but not the signing of treaties, and vice versa. Here, pollution is argued to be identified by Density, Temperature, and Method, while identification of the parameters in the treaties equations comes from the political variables (having elections or not, or having a parliamentary system of not), together with Openness of the economy.

A. Effect of Treaties on the State of the Resource

The first step in assessing the effect of environmental treaties on the state of the water consists of estimating an instrumental variable for treaties. Then, a Probit model for each treaty dummy variable as a function of all the relevant exogenous variables is estimated:

$$\mathrm{Trat}_{it}^{j} = \beta_1 \cdot \mathrm{H}_{it} + \beta_2 \cdot \mathrm{N}_{it} + \varepsilon_{it} \ , \quad j=1,2,3$$

where i is a monitoring station index, t is a time index, ε is the error assumed to have mean zero and finite variance. The variables linked to possible anthropogenic causes of compromised water-quality (GDP per capita, Density, Geographic position with respect to the resource -Up, Down, Frontier-, Openness of the economy, Parliamentary Regime, Elections) are denoted by H_{it}. Variables linked to natural factors (Regions, Temperature, Latitude, Lake) are denoted by N_{it}. The regressions exclude other exogenous variables: Trend (which is not included because the dummy variables for treaty do not have much variation over time since most of the treaties were already signed when data collection began), and Method of Measurement (because it is not expected to influence treaties, and including it would mean adding eight more dummy variables to the regression).

All international monitoring stations (644 observations) are included in the Probit models. Although there is no generally accepted goodness-of-fit measure for Probit estimates, the two most widely used statistics yield acceptable results. The likelihood ratio index is 0.98, 0.45, and 0.33 for treaty types 1, 2 and 3 respectively, so the regression coefficients are relatively far from zero[13]. The percentage of correct predictions (according to the "fit table") are also considered high (0.99, 0.83 and 0.82) and the models do not predict only one outcome.

Once the Probit regressions are performed, the fitted probabilities of signing each type of treaty are used as an instrument in the second step, which consists of estimating the effects of treaties on water quality. The results are divided into two sections, one for the direct indicator of water quality (Dissolved Oxygen), and another for the pollution indicators (BOD, Fecal Coliforms and Nitrate).

1) Direct Water Quality Indicator: Dissolved Oxygen

Table 3 presents the results of the regressions that attempt to capture the effect of treaties on water quality[14]. For all three types of treaties, the apparent effect has the expected sign in the sense that, if the treaty exists, the quality of the water seems to be better. In all cases, these effects are significant at levels lower than 5%. Note also that the corresponding coefficient for general treaties on frontier water (treaty 1) is lower than that of agreements on a specific water resource (treaty 2), which is in turn lower than the coefficient for specific pollution agreements pertaining to particular watersheds (treaty 3).

With respect to the rest of the variables in the regression, temperature always has the expected sign (the warmer the water, the lower its quality), and the coefficient is very statistically significant. The trend seems to suggest that as time passes between 1979 and 1990, the level of dissolved oxygen in all waters has been decreasing[15]. For the other four variables (GDP, Density, Lake and Method) the signs of the coefficients vary across regressions and are generally not significant. However, when GDP is significant it has a positive sign (the larger is income, the higher is water quality)[16]. Method being significant means that the laboratory method used in processing the sample has some importance in terms of the resulting assessment of water quality. This would explain why the first step in a any treaty which includes a monitoring system (e.g., the Rhine river), is to standardise not only the parameters used to measure water quality but also the method employed. Population Density may not be significant mainly because it corresponds to the whole country, while water quality at a monitoring station is most likely influenced by more local parameters. The same is true for GDP, but this variable is different because it may also be an indication of the

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[13] The likelihood ratio index is $1-(\ln L/\ln L_0)$, where $\ln L$ is the maximised likelihood and $\ln L_o$ is the maximised likelihood assuming all the slope coefficients are equal to zero.

[14] Note that fixed effects were used for regions rather than countries because those tend to explain effects on pollution captured by other coefficients such as treaty variables, and so the significance of the latter decreases. The effect of the geographical position of the country with respect to the resource are not reported because they did not yield easy to interpret estimates and its exclusion does not significatively change the results.

[15] The same regressions were run with year dummies. The resulting coefficients followed approximately a linear trend, and the other estimates preserved the same order of magnitude, sign and significance.

[16] The usual relation between environmental quality and GDP is supposed to be cubic (as in Grossman and Krueger, 1995) or quadratic (as in Selden and Song, 1994). These estimations where made focusing on that pairwise relation exclusively. Here, since the goal is to study the link between international environmental treaties and environmental quality, a simple linear relation with GDP is postulated. However, when an attempt was made to evaluate if such specifications would have changed the results, the latter remained approximately similar. Neither the sign nor the statistical significance of the coefficients on the treaty variables changed.

kinds of domestic environmental policies in place in a particular country[17].

***Table 3: Summary table of regression results for the effect of water treaties on the level of Dissolved Oxygen* (# observations = 599)**

	Treaty 1	*Treaty 2*	*Treaty 3*
Cons.	10.4087*	9.5036*	10.0446*
Trend	-0.0457 (0.0324)	-0.0338 (0.0319)	-0.0431 (0.0317)
GDP/cap (IP 1985)	0.0468 (0.0332)	0.1129* (0.0362)	-0.0320 (0.0441)
Density (pop/m^3)	0.0069 (0.0091)	-0.0006 (0.0084)	-0.0078 (0.0093)
Lake	0.0243 (0.4066)	-0.1310 (0.4026)	0.2562 (0.3871)
Method	0.3142 (0.2651)	0.6174* (0.2689)	0.4732* (0.2608)
Temp (^{o} C)	-0.2037* (0.0258)	-0.2107* (0.0245)	-0.1852* (0.0252)
Probability Treaty 1	1.4943* (0.4692)		
Probability Treaty 2		2.4531* (0.9378)	
Probability Treaty 3			2.5755* (0.8307)
Mean Disso2	8.023	8.023	8.023

Note: Standard errors are in parenthesis. The superscript * represents 5% of significance. Constant terms represent the mean of the estimated region effects. The R^2 are not reported because here, as in a two-stage least square estimation, it is not a good indication of fit (Golberger -pp. 371-372-, 1991).

One possible problem with this model is that treaty effects on water quality are analysed as if they were contemporaneous with treaty signing. But adding lagged variables for treaty does not change the results since the great majority of water agreements were already signed before the beginning of the GEMS/Water Program's records (1979). Thus, the intertemporal dimensions are lost due to the nature of the data. The other criticism of this approach is that the signing of a treaty is not equivalent to its actual enforcement and application. The hypothesis behind this paper, however, is that having a treaty on water quality signals some commitment by countries to reduce their pollution levels, and that this commitment must have an actual effect (even if small) on the evolution of resource quality.

2) Indirect Water-Quality Indicators: BOD, Fecal Coliforms, Nitrate

As mentioned above, the measures of indirect water quality considered for the econometric analysis are those with the most observations reported and the largest number of countries represented. Within this group, there is one indicator for oxygen balance, another for microbial pollution and another for nutrients, so that each category of indirect

[17] Except for a 1976 index of "country environmental regulation" produced by UNCTAD -for 23 countries- and used in Tobey (1990), there is no internationally homogeneous measure of domestic environmental policy stringency.

water quality is included. The methodology employed is the same as that for Dissolved Oxygen (using the same first stage Probit estimates for treaties), but the results are not as clear.

Table 4 summarises the coefficients in each of the regressions for pollutants. In these cases, the expected signs for the coefficients on the fitted treaty probabilities are negative because the existence of a treaty should imply a decrease in water pollution. In table 4, those estimates which have a positive sign are not significant. However, treaty 2 seems to have a clear effect on all pollutants, indicating that a treaty on a specific resource (even if it does not imply a policy measure specifically against pollution, as treaty 3 does), might be a better solution to combat pollution than a general treaty on all the common waters as treaty 1.

For the remaining coefficients in the regressions, the point estimates are relatively reasonable. As time passes, there is a significant decrease of the amount of pollutants in bodies of freshwater, except for BOD. The effect of GDP has different signs across each regression. While the coefficients are mostly not significant, they indicate that a higher GDP corresponds more pollution (when they are significant). Population Density seems to play a negative role in the case of Nitrate pollution (which comes mainly from surface runoff with fertilisers). Temperature has very significant effects for both BOD and Fecal Coliforms. The warmer is the water, the more these pollutants are detected. Different Measurement Methods are only reported for Fecal Coliforms but (contrary to the results for Dissolved Oxygen), they do not seem to play a significant role in changing its measure.

Table 4: Summary table of regression results for the effect of water treaties on the level of BOD, Fecal Coliforms and Nitrate

	BOD			*Fecal Coliform*			*Nitrate*		
	Trat1	**Trat2**	**Trat3**	**Trat1**	**Trat2**	**Trat3**	**Trat1**	**Trat2**	**Trat3**
Cons.	-23.087*	-11.799*	-24.196*	-76.801*	-43.363*	-74.287*	5.6412*	4.371*	2.023*
Trend	0.08891	-0.775**	0.1322	-5.2757*	-6.2101*	-5.3254*	-0.2484*	-0.2334*	-0.0921
	(0.4225)	(0.4635)	(0.4648	(2.364)	(2.392)	(2.365)	(0.0833)	(0.0862)	(0.1417)
GDP/ca	1.4588*	-0.1785	1.4071**	1.4403	-0.1591	1.6620	-0.0622	-0.0938	0.2059
	(0.6296)	(0.7149)	(0.8052	(2.674)	(2.782)	(3.524)	(0.0854)	(0.0877)	(0.3685)
Density	-0.187**	-0.0872	-0.1884	21.657	-14.340	21.223	0.2046*	0.2101*	0.2042*
	(0.1159	(0.1229)	(0.1288	(81.55)	(83.39)	(81.44)	(0.0163)	(0.0164)	(0.0198)
Lake	0.91694	16.669*	0.4148	-20.787	-17.056	-21.424	2.6181*	3.2624*	2.6599*
	(6.597)	(7.239)	(6.532)	(71.13)	(71.40)	(71.43)	(0.7658)	(0.9937)	(1.099)
Method				-15.657	-12.354	-14.501			
				(20.69)	(20.79)	(24.18)			
Temp	1.0842*	1.6380*	1.0813*	6.0461*	6.5372*	5.9687*	-0.0462	0.0102	0.0095
	(0.4187)	(0.4483)	(0.4658	(2.173)	(2.119)	(2.131)	(0.0512)	(0.0612)	(0.0932)
Prob. Treaty	-2.0933			4.0087			-2.8258*		
	(5.668)			(57.99)			(0.9835)		
Prob. Treaty		-55.934*			-83.928*			-3.0461*	
		(8.917)			(38.84)			(1.636)	
Prob. Treaty			1.6264			-4.2266			-3.5029
			(18.25)			(42.81)			(4.524)
#Obs.	488	488	488	457	457	457	332	332	332
Mean	8.062	8.062	8.062	22.313	22.313	22.313	2.503	2.503	2.503

Note: Standard errors are in parenthesis. The superscripts * and ** correspond respectively to a 5% and 10% degree of significance. Constant terms represent the mean of the estimated region effects. Fecal Coliforms has been divided by 1,000 to make the coefficients more comparable.

Finally, a test for endogeneity (Hausman, 1978) was performed to confirm the superiority of the two-step procedure relative to the ordinary least squares approach. The statistic $(\hat{b}_{2step} - \hat{b}_{LS})' \cdot (\hat{Var}_{2step} - \hat{Var}_{LS})^{-1} \cdot (\hat{b}_{2step} - \hat{b}_{LS})$, computed for all the above regressions, rejects the null hypothesis of exogeneity in several of them. The clearest rejections are for the Nitrate regressions since the value of the χ^2 statistic greatly surpasses its critical value.

B. The State of the Resource as a Determinant of Treaties

The same four indicators are analysed, but clear results are obtained only for Dissolved Oxygen. The key issue in the estimation methodology employed in part A. is the problem of endogeneity. The same problem arises here since there may be factors that affect pollution and at the same time influence the existence of a treaty, so the two-stage procedure is utilised again. The only difference is that now step 1 is an OLS estimation, and step 2 a Probit equation. Step 1 consists of formulating instruments for the state of the water indicators using the exogenous variables as first-stage regressors:

$$Wq_{it} = \gamma_1 \cdot H_{it} + \gamma_2 \cdot N'_{it} + \nu_{it}$$

where i is a monitoring station index, t is a time index, ν is the error with mean zero and finite variance. The variables linked to possible anthropogenic causes of water-quality (H_{it}) are the same as in IV. A (step 1). The natural factors are also the same, with the only difference being that fixed effects for countries are used instead of fixed effects for regions. The regressions also include a dummy for the Measurement Method, and a time trend because it is expected that as time passes, water quality changes. The resulting R^2 for this first-stage regression is 0.44.

***Table.5: Summary table of regression results for treaties as the dependent variable** (# observations = 599)*

	Treaty 1	*Treaty 2*	*Treaty 3*
Cons.	1.5300*	0.2390*	-0.7771*
GDP/cap (IP 1985)	0.0004* (0.00004)	0.0001* (0.00002)	0.0002* (0.00002)
Lake	-0.6274** (0.3504)	-0.7980* (0.2386)	-0.5950* (0.3023)
Openness	-0.0027** (0.00152)	-0.0011 (0.00089)	-0.0009 (0.00086)
Parliament	-0.5075 (0.2704)	-0.8372* (0.1786)	0.0568 (0.1547)
Elections	0.4826 (0.2348)	-0.1103 (0.1628)	-0.7838* (0.1931)
Fitted Water Quality	-0.2596* (0.0609)	0.0834* (0.02707)	-0.0159 (0.0276)
Likelihood	0.64	0.25	0.21
Fit probability	0.94	0.77	0.76

The results of the two-step procedure for the treaty equation are summarised in table 5. The expected sign for ϕ_3 (better water quality, less probability of a treaty) was obtained for treaty 1 (treaties on general border waters) and treaty 3 (treaties on pollution for specific waterbeds). It was significant for treaty 1. These results are not consistent with the expectations in the sense that the more polluted is a lake or river, the more incentives there should be to sign a very specific agreement on pollution of that waterbody.

The rest of the estimates suggest that countries with higher GDP have a higher probability of having an international environmental treaty for some station at a given point in time. In addition, the empirical relationships between the existence of water treaties and the political variables do not seem to be very stable.

V. Summary and Conclusions

This study indicates that water treaties appear to have an effect on water quality. Moreover, the more a watershed is under the influence of specific treaties which deal with its pollution, the better is the state of its water. In other words, what here have been called treaties of type 1 (general treaties on all frontier waters) are less effective than treaties of type 2 (treaties on a particular watershed), and those have less impact on water quality than treaties of type 3 (agreements specifically on pollution of a particular river or lake). In addition, deteriorating water quality appears to influence treaty signing only on the management of frontier waters (treaty 1). These results are exhibited by Dissolved Oxygen, which is not only the sole direct measure of water quality, but also the one with most observations and more countries reported in the sample. In terms of the three other measures of pollution analysed (BOD, Fecal Coliforms and Nitrate), the results are not so clear. For example, only treaties of type 2 seem to have had an impact in reducing the levels of these indicators.

This research does not intend to be conclusive, either about the effectiveness of environmental treaties, or about their determinants. There are surely problems of reliability of the data and also difficulties in capturing separately the impact of the different variables on treaty signing and on water quality. In particular, political factors (which here are thought to help identify the equations modelling the effects of treaties on pollution) may also in fact influence water quality if they are viewed as a indirect measure of the stringency of domestic environmental regulations. The clearest example (for another time frame than the dataset utilised here) is the case of the former Soviet Union republics, whose change of regime surely influenced environmental quality. Another limitation of the data is that the time dimension of the treaties is lost because most of them were signed before the inception of record-keeping for these data. Hence, all the explanatory power for the link between treaties and water quality stems from the comparison between stations that are international but do not have a treaty and those that do have treaties. There is no way to capture what was the quality of the resource before and after the treaties were signed for both kinds of stations. There are also some factors which may be important in determining environmental policy in general which are not included even if theoretically they are considered to play a role. For example, political variables are limited to the government being elected or not and the political system being parliamentary or not, while the facts show that the existence of ecological groups, the proficiency of the environmental bureaucracy or even the party system may influence the environmental regulations[18].

However, the primary goal of this study has been achieved, since it provides some results (even if preliminary) which may stimulate the development of better-specified models to be tested with improved data in the future. In addition, and more immediately, this methodology could be useful in studying the effects of specific treaties (or protocols for reducing particular pollutants within those treaties), which have longer, wider and more-controlled datasets. This could be possible for a subset of the most important treaties which have long-running monitoring programs in place (e.g., the Rhine river, the Moselle and Saar, the Great Lakes, etc.). As international treaties continue to evolve and proliferate, careful empirical assessments of their effectiveness can only become more important.

[18] An example of the latter variable's influence can be evaluated by considering the difference between the German regulation and the UK environmental policy. In the former country, parties in coalitions govern (of which the Greens), while the majority party takes all the decisions. Then, even if both countries have ecological groups, the degree of their representation in decision making is very different and that translates in very different strengths of their environmental policy.

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Appendix A: International Monitoring Stations

The original sample from GEMS/Water contains data from international stations in five regions (Europe, America, Africa, the Middle East and South east Asia).

1. Europe

International waters for which there are observations of several countries:
Rhine basin: For the Rhine river, there are monitoring stations in Germany (135001 MAXAU, 135002 MAINZ, 135003 KOBLENZ/BRAUBACH , 135006 KLEVE/BIMMEN), and the Netherlands (46001 AT GERMAN FRONTIER, 46002 BOVEN MERWEDE, 46003 LEX, 46004 IJSSEL). For the Mosel, there are two stations in Germany (135004 PALZEM, 135005 KOBLENZ). For the Sure river, one station is in Belgium (51014 MARTELANGE), and the other in Luxembourg (16001 WASSERBILLIG).

Danube basin: For the Danube river, there is one monitoring station in Germany (135012 JOCHENSTEIN) and another in Hungary (66002 AT BUDAPEST). There is also one station in Hungary for the Tisza river (66001 AT SZOLNOK).

Tajo river: There is one station in Portugal (73001 AT SANTAREM) and another in Spain (75004 EN PTE BARCA)

Then, there are observations for other rivers in Europe for which there is information for only one of the countries that share the resource. Those monitoring stations are presented by country and river:

In Belgium: Scheldt River (51009 DOEL, 51010 BLEHARIES, 51015 ZELZATE - GHENT/TERNEUZEN)
Meuse River (51012 HEER/AGIMONT, 51013 LANAYE/TERNAAIEN)
Escaut River (51001 AT BLEHARIES)
Lys River (51007 WARNETON)
Espierre River (51008 LEERS/NORD)
Sambre River (51011 ERQUELINNES)

In Finland: Tornionjoki River (65001 STN 14100)
In France: Garonne River (12051 MARMANDE, 12052 VALENCE D'AGEN, 12053 FENOUILLET)
Rhone River (12061 ST. VALLIER, 12063 LYON, 12064 COLLONGES)

In Germany: Niers River (135007 GOCH)
Ems River (135008 HERBRUM)
Elbe River (135011 GEESTHACHT)

In Italy: Po River (68006 BORETTO, 68008 PONTELAGOSCURO)

In Netherlands: Maas River (46005 AT BELGIAN FRONTIER)

In Spain: Miño River (75002 EN PTE MAYOR OROZA)
Guadiana River (75005 EN PTE PALMAS BA01A)
Ebro River (75006 EN MENDAVIA NA01A)

2. America

In ***North America***, the monitoring stations common to several countries are on the following rivers and lakes:

Great Lakes: For Lake Huron, in Canada (39008) and in the United States at St. Clair River (28019). For Lake Superior, in Canada (39011) and in the US at St. Marys River (28018). For lake Ontario, in Canada (39010) and in the US at Niagara River (28020).

St. Lawrence basin: For the St. Lawrence river, in Canada (39003) and in the US (28021). For the St. John river, in Canada (39012).

Colorado River: In Mexico (37001) and in the United States (28006).

Río Bravo or Río Grande: In Mexico (37003) and in the US (28010). Two related stations in Mexico are at Rio Conchos (37002) and at Presa de la Amistad (37010).

Then, there are rivers for which samples of only one country are reported:

In Canada:	Nelson River (39002, 39099)
	Saskatchewan River (39004)
	Roseau River (39006)
	Fraser River (39007)
In the US:	Columbia River (28002)
	Yukon River (28003)
In Mexico:	Río Usumacinta (37015)
	Río Grijalba (37016)

In ***South America***, the monitoring stations common to several countries are all on the *River Plate basin*:

Río Paraná: There are three stations in Argentina (1001 PUERTO LIBERTAD, 1002 CORRIENTES, 1004 ROSARIO), and three stations at tributaries in Brazil (RIO PARAIBA DO SUL 2002-APARECIDA, 2006-BARRA MANSA, and 2008 RIO JACUI). There is also one station at the Paraguay river in Argentina (1003 PUERTO BERMEJO).

Río Uruguay: Two monitoring stations in Argentina (1006 CONCEPCION DEL URUGUAY, 1007 EMBALSE SALTO GRANDE) and two in Uruguay (48015 SALTO, 48038 BELLA UNION).

Río de La Plata: In Argentina (1005 BUENOS AIRES) and in Uruguay (48039 COLONIA).

3. Africa

The rivers and lakes for which there are monitoring stations in several countries are:

Lake Victoria: In Kenya (112002, 112008 KISUMU), in Tanzania (104001 SOUTH PORT, 104007 BUKOBA), and in Uganda (110001 AMUCHION BAY).

Nile Basin: In Uganda (110002 LAKE KYOGA, 110003 LAKE MOBUTO -SESE SEKO ALBERT NILE, 110007 MOBUTO NILE AT PAKWACH, 110004 JINJA NILE) and in Tanzania at the Kagera River (104003 NYAKANYASI).

There are other rivers only reported for one country:

In Mali: Niger River (99001 AT BAMAKO -DJIKORONI-, 99002 UPSTREAM BAMAKO KENIEROB)

In Senegal : Senegal River (100002 PRISE D'EAU A ST. LOUIS)

In Tanzania: River Ruvu (104004 RUVU MLANDIZI)

In Zaire: River Zaire (98001)

4. Middle East

The only waterbody for which there are stations in several countries is:

Nile Basin: There are observations which also belong to Africa and correspond to the Nile river in Egypt (10002 AT ASWAN, 10003 AT ASSIUT, 10004 AT EL SHOBAK, 10005 IN CENTRE OF CAIRO, 10006 AT EL KANATER, 10007 DAMIETTA BRANCH AT FARSKUR, 10008 ROSETTA BRANCH AT EDFINA), to the Blue Nile in Sudan (78002 AT KHARTOUM) and to the Jebel Aulia Reservoir in Sudan (78001).

Some rivers and lakes have observations for only one country:

In Iran: Karun River (14010 IN AHWAZ CITY)

In Jordan: King Talal Dam (69003)

In Pakistan: There are several stations for the *Indus river basin*, which correspond to the Ravi River (56003 UPSTREAM LAHORE, 56004 DOWNSTREAM LAHORE), the Lower Chenab River (56005 GUJRA BRANCH) and the Indus River (56006 AT KOTRI).

5. South-East Asia

In this region all rivers have reports from only one of the countries sharing them:

In Bangladesh: There are several stations that monitor the *Ganges basin*, located at the Lower Ganges River (136002 PADHA), the Brahmaputra River (136003), the Meghna River (136004) and the Surma River (136005).

In Thailand: Chao Phrya River (54002 D/S NAKHON SAWAN).

Appendix B: Regressions to Fill in Missing Data on Water Temperature

Reference regressions are run for the cases which include temperature. Those situations can be classified into different cases according to the information available on elevation of the station, depth of the water and discharge at the monitoring station from which the observation is taken:

Different cases of stations for which temperature is reported

	Rivers				Lakes		
Height	Yes	Yes	-	-	Yes	Yes	-
Depth	Yes	-	-	-	Yes	-	-
Discharge	Yes	Yes	Yes	-			

The OLS regressions have the temperature reported as the dependent variable. The independent variables which are common to all the data are Latitude, Southern Hemisphere, and Regions. Height, Depth and Discharge are also present for some observations. The coefficients of reference regressions are then used to complete the series on temperature in the following situations:

Different cases of stations for which temperature is not reported

	Rivers						Lakes		
Height	Yes	Yes	-	Yes	Yes	-	Yes	Yes	-
Depth	Yes	-	-	Yes	-	-	Yes	-	-
Discharge	Yes	Yes	Yes	-	-	-			

Note: There is one observation for rivers for which only discharge and depth are available.
It is assumed as if none of the three variables was reported.

The results of the reference regressions are:

Results of regressions run with observations which have temperature reported

	Rivers						*Lakes*		
Height	-0.0044	-0.0045		-0.00437	-0.0043		-0.0036	-0.0032	
Depth	-0.0219			-0.0013			-0.0199		
Discharge	0.00009	0.00006	0.00013						
Latitude	-0.00011	-0.00010	-0.00008	-0.00009	-0.00009	-0.00008	-0.00013	-0.00014	-0.00013
$\mathbf{R^2}$	0.84	0.83	0.79	0.80	0.76	0.78	0.83	0.82	0.75
# Obs.	547	567	700	990	1061	1408	302	306	325

Note: Coefficients for Latitude, Southern Hemisphere, and Regions are not reported.

Appendix C: Program for the Econometric Estimations

```
? Read data
READ;File=C:\QPW\MCGRAND\DATAH20.wk1;Format=wks;Names $
OPEN;Output=C:\LIMDEP\AGUA.OUT $

? Describe the data: statistics
 ? For Rivers
SAMPLE;ALL$
REJECT;GROUND=1+LAKE=1$
? Whole sample
skip
DSTAT;Rhs=DISSO2,BOD,COD,FECAL,COLIF,ARSEN,NICKEL,MERC,CADM,LEAD,NITR$
? International observations
REJECT;UP=0&DOWN=0&FRONT=0$
skip
DSTAT;Rhs=DISSO2,BOD,COD,FECAL,COLIF,ARSEN,NICKEL,MERC,CADM,LEAD,NITR$
? For Lakes
SAMPLE;ALL $
REJECT;GROUND=1$
REJECT;LAKE=0$
? Whole sample
skip
DSTAT;Rhs=DISSO2,BOD,COD,FECAL,COLIF,ARSEN,NICKEL,MERC,CADM,LEAD,NITR$
? International observations
REJECT;UP=0&DOWN=0&FRONT=0$
skip
DSTAT;Rhs=DISSO2,BOD,COD,FECAL,COLIF,ARSEN,NICKEL,MERC,CADM,LEAD,NITR$

? Organizing the data
SAMPLE;ALL$
NAMELIST;Regions=AFR,AMR,EMR,EUR,SEA,WPR$
NAMELIST;Regions1=AMR,EMR,EUR,SEA,WPR$
NAMELIST;Regions2=AFR,AMR,EMR,EUR,SEA$
CREATE;DENS=POP/AREA$
CREATE;FECAL=FECAL/1000$
CREATE;GDP=GDPL/1000$

? Auxiliary regressions for temperature
 ? Rivers
SAMPLE;ALL$
REJECT;LAKE=1+GROUND=1$
skip
REGRESS;Lhs=TEMP;Rhs=HEIGHT,DEPTH,DISCH,LAT,HSUR,Regions1$
REGRESS;Lhs=TEMP;Rhs=HEIGHT,DISCH,LAT,HSUR,Regions1$
REGRESS;Lhs=TEMP;Rhs=DISCH,LAT,HSUR,Regions$
REGRESS;Lhs=TEMP;Rhs=HEIGHT,DEPTH,LAT,HSUR,Regions$
REGRESS;Lhs=TEMP;Rhs=HEIGHT,LAT,HSUR,Regions1$
REGRESS;Lhs=TEMP;Rhs=LAT,HSUR,Regions$
REGRESS;Lhs=TEMP;Rhs=LAT,Regions$
REGRESS;Lhs=TEMP;Rhs=ONE,LAT$
 ? Lakes
SAMPLE;ALL$
REJECT;LAKE=0&GROUND=1+LAKE=O&GROUND=0$
skip
REGRESS;Lhs=TEMP;Rhs=HEIGHT,DEPTH,LAT,HSUR,Regions$
```

```
REGRESS;Lhs=TEMP;Rhs=HEIGHT,LAT,HSUR,Regions$
REGRESS;Lhs=TEMP;Rhs=LAT,HSUR,Regions$
REGRESS;Lhs=TEMP;Rhs=LAT,Regions$
REGRESS;Lhs=TEMP;Rhs=ONE,LAT$

? 1) Effects of treaties on water quality

? Instrumentalize treaties
 SAMPLE;ALL$
REJECT;GROUND=1$
REJECT;UP=0&DOWN=0&FRONT=0$
PROBIT;Lhs=Trat1;Rhs=
GDPL,DENS,UP,DOWN,FRONT,OPEN,PARL,ELECT,REGIONS2,DEDTEMP,LAT,LAKE;KEEP=ETRA
T1$
CREATE;BTRAT1=B(1)*GDPL+B(2)*DENS+B(3)*UP+B(4)*DOWN+B(5)*FRONT+B(6)*OPEN+B(7)*P
ARL+
B(8)*ELECT+B(9)*AFR+B(10)*AMR+B(11)*EMR+B(12)*EUR+B(13)*SEA+B(14)*DEDTEMP+B(15)*L
AT+
B(16)*LAKE$
CREATE;PBTRAT1=PHI(BTRAT1)$
PROBIT;Lhs=Trat2;Rhs=
GDPL,DENS,UP,DOWN,FRONT,OPEN,PARL,ELECT,REGIONS2,DEDTEMP,LAT,LAKE;KEEP=ETRA
T2$
CREATE;BTRAT2=B(1)*GDPL+B(2)*DENS+B(3)*UP+B(4)*DOWN+B(5)*FRONT+B(6)*OPEN+B(7)*P
ARL+
B(8)*ELECT+B(9)*AFR+B(10)*AMR+B(11)*EMR+B(12)*EUR+B(13)*SEA+B(14)*DEDTEMP+B(15)*L
AT+
B(16)*LAKE$
CREATE;PBTRAT2=PHI(BTRAT2)$
PROBIT;Lhs=Trat3;Rhs=
GDPL,DENS,UP,DOWN,FRONT,OPEN,PARL,ELECT,REGIONS2,DEDTEMP,LAT,LAKE;KEEP=ETRA
T3$
CREATE;BTRAT3=B(1)*GDPL+B(2)*DENS+B(3)*UP+B(4)*DOWN+B(5)*FRONT+B(6)*OPEN+B(7)*P
ARL+
B(8)*ELECT+B(9)*AFR+B(10)*AMR+B(11)*EMR+B(12)*EUR+B(13)*SEA+B(14)*DEDTEMP+B(15)*L
AT+
B(16)*LAKE$
CREATE;PBTRAT3=PHI(BTRAT3)$

? How do treaties affect water quality?
SKIP
REGRESS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT1$
MATRIX;BD1=B;VARD1=VARB;SD1=S^2$
2SLS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT1;
Inst=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,PBTRAT1$
MATRIX;BID1=B;VARID1=VARB;SID1=S^2$
REGRESS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT2$
MATRIX;BD3=B;VARD3=VARB;SD3=S^2$
2SLS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT2;
Inst=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,PBTRAT2$
MATRIX;BID3=B;VARID3=VARB;SID3=S^2$
REGRESS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT3$
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MATRIX;BD4=B;VARD4=VARB;SD4=S^2$
2SLS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,TRAT3;
Inst=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,PBTRAT3$
MATRIX;BID4=B;VARID4=VARB;SID4=S^2$
REGRESS;Lhs=DISSO2;
Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,
MDISSO2,DEDTEMP,TRAT1,TRAT2,TRAT3 $
2SLS;Lhs=DISSO2; Rhs=REGIONS2,TREND,GDP,DENS,UP,DOWN,FRONT,LAKE,
MDISSO2,DEDTEMP,TRAT1,TRAT2,TRAT3; Inst=REGIONS2,TREND,GDP,DENS,UP,
DOWN,FRONT,LAKE,MDISSO2,DEDTEMP,PBTRAT1,PBTRAT2,PBTRAT3$

? How do treaties affect pollution?
SAMPLE;ALL$
skip
REGRESS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT1$
MATRIX;BD1=B;VARD1=VARB;SD1=S^2$
2SLS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT1
;Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT1$
MATRIX;BID1=B;VARID1=VARB;SID1=S^2$
REGRESS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT2$
MATRIX;BD3=B;VARD3=VARB;SD3=S^2$
2SLS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT2
;Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT2$
MATRIX;BID3=B;VARID3=VARB;SID3=S^2$
REGRESS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT3 $
MATRIX;BD4=B;VARD4=VARB;SD4=S^2$
2SLS;Lhs=BOD;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT3
;Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT3$
MATRIX;BID4=B;VARID4=VARB;SID4=S^2$

SAMPLE;ALL$
SKIP
REGRESS;Lhs=FECAL;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRA1$
MATRIX;BD1=B;VARD1=VARB;SD1=S^2$
2SLS;Lhs=FECAL;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRAT1;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,PBTRAT1$
MATRIX;BID1=B;VARID1=VARB;SID1=S^2$
REGRESS;Lhs=FECAL;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRA3$
MATRIX;BD3=B;VARD3=VARB;SD3=S^2$
2SLS;Lhs=FECAL; Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRAT2;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,PBTRAT2$
MATRIX;BID3=B;VARID3=VARB;SID3=S^2$
REGRESS;Lhs=FECAL;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRA4$
MATRIX;BD4=B;VARD4=VARB;SD4=S^2$
2SLS;Lhs=FECAL;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,TRAT3;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,MFECAL,DEDTEMP,PBTRAT3 $
MATRIX;BID4=B;VARID4=VARB;SID4=S^2$

SAMPLE;ALL$ SKIP
REGRESS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT1$
MATRIX;BD1=B;VARD1=VARB;SD1=S^2$
2SLS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT1;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT1 $
MATRIX;BID1=B;VARID1=VARB;SID1=S^2$
REGRESS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT2$
MATRIX;BD3=B;VARD3=VARB;SD3=S^2$
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2SLS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT2;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT2 $
MATRIX;BID3=B;VARID3=VARB;SID3=S^2$
REGRESS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT3$
MATRIX;BD4=B;VARD4=VARB;SD4=S^2$
2SLS;Lhs=NITR;Rhs=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,TRAT3;
Inst=REGIONS2,TREND,GDP,DENS,LAKE,DEDTEMP,PBTRAT3 $
MATRIX;BID4=B;VARID4=VARB;SID4=S^2$
? Hausman Endogeneity test
CALC;S1=SID1/SD1$
CALC;S3=SID3/SD3$
CALC;S4=SID4/SD4$
MATRIX;VARDD1=S1*VARD1$
MATRIX;VARDD3=S3*VARD3$
MATRIX;VARDD4=S4*VARD4$
MATRIX;DD1=BD1~BID1$
MATRIX;DD3=BD3~BID3$
MATRIX;DD4=BD4~BID4$
MATRIX; HD1= DD1'|Nvsm(VARID1,-VARDD1)|DD1$
MATRIX; HD3= DD3'|Nvsm(VARID3,-VARDD3)|DD3$
MATRIX; HD4= DD4'|Nvsm(VARID4,-VARDD4)|DD4$

? 2) Poor water quality as a deteminant of treaty signing

? Instrumentalize pollution
REGRESS;Lhs=DISSO2; Rhs=D80,D81,D82,D83,D84,D85,D86,D87,D88,D89,D90,
LAT,GDPL,DENS,UP,DOWN,FRONT,LAKE,DEDTEMP,
AR,BA,BE,BR,CA,EG,GE,FI,FR,LU,HU,IR,IT,JO,KE,ML,ME,NE,PA,PO,SE,SP,
SU,TH,UG,TA,US,UR,ZA,MDISSO2,OPEN,PARL,ELECT; KEEP= EDISSO2 $
REGRESS; Lhs=BOD; Rhs=D80,D81,D82,D83,D84,D85,D86,D87,D88,D89,D90,
LAT,GDPL,DENS,UP,DOWN,FRONT,LAKE,DEDTEMP,
AR,BA,BE,BR,CA,EG,GE,FR,LU,HU,IR,JO,KE,ML,ME,NE,PA,PO,SP,
SU,TH,TA,US,UR,ZA,OPEN,PARL,ELECT; KEEP= EBOD $
REGRESS; Lhs=FECAL; Rhs=D80,D81,D82,D83,D84,D85,D86,D87,D88,D89,D90,
LAT,GDPL,DENS,UP,DOWN,FRONT,LAKE,DEDTEMP,
AR,BA,BE,BR,CA,FR,LU,HU,IR,IT,JO,ME,NE,PA,PO,SP,
TH,TA,US,UR,MFECAL,OPEN,PARL,ELECT; KEEP= EFECAL $
REGRESS; Lhs=NITR; Rhs=D80,D81,D82,D83,D84,D85,D86,D87,D88,D89,D90,
LAT,GDPL,DENS,UP,DOWN,FRONT,LAKE,DEDTEMP,
AR,BA,CA,EG,GE,HU,IR,KE,ME,NE,PA,PO,SE,SP,
SU,TH,UG,TA,US,UR,OPEN,PARL,ELECT; KEEP= ENITR $

? How do quality and pollution affect treaties?
 skip
PROBIT;Lhs=Trat1;Rhs=GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EDISSO2 $
PROBIT;Lhs=Trat2;Rhs=GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EDISSO2 $
PROBIT;Lhs=Trat3;Rhs=GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EDISSO2 $
PROBIT; Lhs=Trat1; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EBOD $
PROBIT; Lhs=Trat2; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EBOD $
PROBIT; Lhs=Trat3; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EBOD $
PROBIT; Lhs=Trat1; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EFECAL$
PROBIT; Lhs=Trat2; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EFECAL$
PROBIT; Lhs=Trat3; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,EFECAL$
PROBIT; Lhs=Trat1; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,ENITR $
PROBIT; Lhs=Trat2; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,ENITR $
PROBIT; Lhs=Trat3; Rhs=ONE,GDPL,UP,DOWN,FRONT,LAKE,OPEN,PARL,ELECT,ENITR $
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