

Hydro-politics: Socio-economic Analysis of International Water Treaties

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Abstract

Water resource issues are closely related to property rights issues, as the holders of property rights along a river bank, watershed, lake, or river basin, often take priority in terms of water usage. Rivers, aquifers and other bodies of water transgress national boundaries, giving rise to conflicts. Treaties, agreements, and conventions seek to allocate water rights among countries in a manner that benefits all participants. This study conducts an empirical analysis of macroeconomic, geological, hydrological, and institutional variables in order to determine factors contributing to the existence of bilateral treaty and treaty structure. (JEL K330)

I. Introduction

There are more than two hundred river basins in the world that are currently shared by two or more countries, distributed across Africa, North America, South America, Asia, and Europe. These basins cover approximately 47% of the earth's total landmass. Rapidly growing water needs of individuals and societies are intensifying pressure on these scarce, overexploited and degraded freshwater supplies, leading to potential conflicts.

Rivers, aquifers and other bodies of water often transgress national boundaries, giving rise to major economic and environmental concerns. When a river flows through two or more sovereign states, it is defined as an international river. These rivers may be used to draw international boundaries, may serve as international highways for countries without direct access to the sea, and may serve non-navigational purposes, such as irrigation, fishing and the production of hydroelectric energy. International law prohibits any country sharing an international water body (river or lake) from causing harm to other countries by overexploitation or degradation of the water body, nonetheless conflicts arise.

Upper riparian rights-holding nations usually claim absolute territorial sovereignty, proclaiming the right to exploit the water source, regardless of the effects of this water use on riparian countries. Lower riparian nations seek to preserve the absolute integrity of the water source, claiming that the upper riparian states should not adversely affect the quality or the quantity of water. Cooperation between states that share international water basins is difficult to achieve, especially when sovereignty, territorial integrity, and security are at stake. Furthermore,

negotiations and opportunities for joint development of water resources are constrained by imbalances in economic, political or military powers among the countries involved and due to the asymmetric availability of information.

Although, to the best of our knowledge, no quantitative studies of bilateral, international water treaties have been conducted, there is a sizeable body of literature on water rights, for example, Ditwiler (1975), Johnson, Gisser, and Werner (1981), Ostrom (1962), Dudley (1992).

There is also a sizeable body of literature on apportionment and river basin management.

Wescoast (1995) presents an historical account of multilateral water agreements over the past three centuries; Becker and Easter (1998) consider water conflicts in the light of externalities and open access public goods using co-operative game theory. Just and Netanyahu (1998) discuss the doctrines and guidelines for water apportionment among countries. Krutilla and Eckstein (1969) analyze the relative efficiency of river development projects at any particular instance to national income and product redistribution, as compared to other projects. Biosson de Chazournes (1998) examines the management of the Aral Sea Basin, while Hirji and Grey (1998) examine transboundary water resources in Africa and find that negotiations for the joint development of shared water resources are constrained by capacity imbalances between countries. Dellapenna (1994) demonstrates that international law plays a crucial role in fostering cooperation over shared water and preventing future conflicts.

This research examines international river basin management through the analysis of bilateral water treaties. While international river basin management involves social, political, economic,

and ecological dimensions, this study concentrates on economic and socio-political factors rather than on ecology.

The study is divided into two stages. The first stage involves estimation of the influences of economic resource constraints, geography, politics, and culture on the existence of bilateral water treaties in international river basins. The second stage analyzes the structure of active bilateral water treaties in terms of explicit stipulations for information sharing, conflict resolution, monitoring and enforcement.

Section two discusses treaties as a means of assigning property rights and related economic research. In section three, the data used in this analysis is discussed. Section four entails the conceptual model and empirical results of the analysis of the existence of bilateral treaties. The fifth section presents the conceptual model and empirical results of the analysis of the bilateral treaty structure. The final section presents the conclusions derived from the study.

II. Background

Water resource issues are closely related to property rights issues, as the holders of property rights along a river bank, watershed, lake, or river basin often take priority in terms of water usage. Therefore, no discussion of water resource economics can proceed without a discussion of property rights. A commonly used definition of property rights states that the right to a given resource implies the ability to control the use of that resource and to exclude others from using it. The resource must be defined, enforceable and transferable.

Demsetz (1967) states that property rights are an instrument of society and are significant insofar as they help people form expectations in dealings with others. These expectations find expression in the laws, customs, and mores of a society. Demsetz argues that property rights arise when it becomes economic for those affected by externalities to internalize benefits and costs. According to Cheung (1970), externalities are attributable to either one or more of three specific reasons: the absence of the right to contract, the presence of a contract with incomplete stipulations, or the presence of stipulations that are inconsistent with marginal equalities.

Contracts between / among nations to establish rights and obligations among themselves might take the form of a treaty, an agreement, or a convention. The term “treaty” indicates four conditions. First, a treaty is a binding instrument, which means that the contracting parties intend to create legal rights and duties. Second, states or international organizations with treaty-making power must conclude the instrument. Third, treaties must be governed by international law. Finally, a treaty must be in writing. “Agreements” are less formal and frequently deal with economic, cultural, scientific and technical cooperation.

A more recent development in international water law is the concept of a “convention.” On May 21, 1997, the General Assembly of the United Nations ratified a convention on international watercourse systems for non-navigable use. The articles of this convention deal with two major concepts. First, the articles address the principles of equitable and reasonable waterway usage, which govern shared water resources and have their roots in the judicial practices of federal states such as the United States. Second, the articles introduce the ‘no harm’ rule, which covers

a whole range of neighborly relations, including issues pertaining to the protection of the environment.

Treaties, agreements, and conventions seek to allocate water rights among countries in a manner that benefits all participants. The work of Just and Netanyahu (1998) allows us to review the standard approaches to the allocation of rights in water disputes, as well as the usual obstacles that prevent the countries or regions involved from reaching mutually beneficial agreements. In their paper, Just and Netanyahu discuss the doctrines and guidelines for water apportionment among countries. The six main apportionment theories are referred to as prior appropriation, the Harmon Doctrine, riparian rights, mutual development theory, the linkage principle, and the Helinski Rules.

The goals of formal contracts and apportionment theories include equitable and/or efficient allocation of water through river management. However, there are obstacles to the formation of sustainable treaties that assure proper allocation and are beneficial to all participants. (Just and Netanyahu, 1998) These include:

1) *Asymmetric Information*: The countries involved in disputes usually have asymmetric access to necessary information or data because of differing ability to process data. Information unavailable to other countries gives a country that owns it a better position in negotiating with other riparian countries. In other words, one country can use the information or data to formulate a strategic advantage over another country.

- 2) *Scientific Gaps and Technical Uncertainties*: Missing information can be strategic or scientific. Scientific gaps create uncertainty with respect to water quality or quantity, such as quantifying the amount of water resources in an aquifer.
- 3) *Enforcement Limitation*: An agreement requires enforcement in order for it to be successful. This in turn requires monitoring which has three major limitations: high cost, technical feasibility or the lack thereof, and sovereignty. International legal rules do not have effective enforcement power, and only offers guidelines for water allocation. A nation may decide not to expose itself to the international court or accept a third party ruling.
- 4) *Sovereignty*: Typically, it is in a country's best interest to protect its absolute sovereignty. A decision that decreases the right of a country to a river basin is not going to be accepted.
- 5) *Conflicting National and International Interests*: While negotiating a basin related treaty, a country often faces competing pressures from domestic regions and neighboring countries. Domestic interest groups often oppose the international position and complicate the negotiations.
- 6) *Asymmetric Country Characteristics*: There are differences in the national per capita income, natural resources, military power, etc. among states. These differences affect the ability of a country to bargain for its share of water in the river basin.
- 7) *Upstream and Downstream Considerations*: The geographic location of a country is also an important factor in determining its power over the coalition. The country that controls the source of the water potentially holds a major position in the negotiation process. For example, Syria has a dominant position over Jordan as it controls four major sources of the Yarmouk River that flows into Jordan.

Hirji and Grey (1998) examine the management of the Nile basin and conclude that several points are of the utmost importance in the formulation of an effective treaty. National capacity must be built and strengthened, information asymmetry must be corrected, and dialogue must develop on diverse issues with the goal of seeking common ground. Participants must come to the negotiating table with objectives to achieve an understanding rather than creating a stalemate due to formulaic demands. The countries in question must recognize that trust must be established, and that opportunities may lie in the use of the water resource in question, thus leading to a win-win situation for all of the countries involved.

Dellapenna (1994) states that the ideal management of international water bodies requires not only formal legal order, but also cooperative management. This cooperative management should be capable of determining the facts of water usage in each country, resolving disputes, responding to temporary water shortages, designing and implementing solutions to permanent shortages of water, and enforcing decisions.

The European Union, the UNDP, the World Bank and other donors provided support in assisting five countries to reach a long-term solution, which led to the adoption of Aral Sea Basin Program (ASBP) in January 1994. International water law was identified as a tool that could contribute to the objectives of the ASBP. Yet for the rule of international law to be sustainable, clear relationships must exist between the countries involved. If such cooperation does not exist, effective water management of a given water system becomes exceedingly difficult.

This research will add to this body of literature on international water treaties through quantitative analysis of the influence of macroeconomic variables, economic and socio-political asymmetries, geographical characteristics, and water usage on the origin and structure of bilateral water treaties.

III. Data

Hamner and Wolf (1997) contributes valuable information to the framework surrounding water treaties of 145 existing treaties, 86% of these treaties are bilateral and 14% are multilateral. The treaties are mostly bilateral because the difficulty of negotiation increases with each increase in the number of parties involved. Hamner and Wolf summarize the general findings from comparative assessments of river basin treaties that are compiled in a database called the Transboundary Freshwater Dispute Database (TFDD). The collection includes water related treaties and 39 U.S. inter-state compacts dating from 1870 to the present. The TFDD contains information regarding the basins involved in treaties, the principal focus of the management of the basins, the number of signatories to a given treaty, the non-water linkages (such as, money, land or other concessions) of a given treaty, the provisions for information sharing, monitoring, conflict resolution, and enforcement provided by a given treaty or agreement, the method and amount of water diversion acceptable under the terms of the treaty, and the date on which the agreement was signed.

Due to time constraints for the purpose of this study, 55 bilateral treaties (110 observations) dating from 1922 to 1996, related to river basin development, along with 73 river basins without treaties (146 observations), were examined. The data, which examines international rivers, is

taken from each continent of the world, with the exception of Australia and Antarctica. Much of the treaty specific and water basin data used in this research is from the TFDD. This data is supplemented by GDP, international trade, area of a country, population, and annual water freshwater withdrawals, as well as facts pertaining to national governments, languages, and ethnicities, which are obtained from the International Financial Statistics Yearbook, the Penn World Table 5.6, and the World Bank.

IV. Empirical Analysis of Treaty Existence

A logistic model is estimated to analyze variables contributing to the existence of bilateral treaties between two countries sharing a river basin. As discussed above, the existence or non-existence of treaties depends upon macroeconomic variables, geographical variables, hydrological variables and institutional variables. The model estimated in this study is as follows:

Treaty = f(difference in GDP between countries, % of international trade, trade partners, Area of individual countries, basin area within individual countries, percentage of the basin area within a country, percentage of water withdrawals associated with agriculture, percentage of water withdrawals for domestic use, political similarity, similarity in language and tradition)

Treaty equals 1 if a treaty exists, 0 otherwise. Non-existence of treaty may be attributable to existing disagreements, or to the lack of need for formal contracts.

Difference in GDP between countries is designed to measure the economic disparity between two countries sharing a river basin. The expected sign of the coefficient is negative, indicating that countries with greater disparities in GDP are less likely to form treaties. The reasoning behind this hypothesis is that countries with greater economic equality are more likely to engage in formal conflict resolution mechanisms.

Percentage of international trade is the sum of a given country's exports and imports, measured as a percentage of the country's GDP. The expected sign of the coefficient is ambiguous, because a high percentage of trade could indicate either a broad and diversified trade base (leading to a higher degree of economic independence from neighboring countries), or a heavy reliance on trade with neighboring countries. In the case of the former, the expected sign would be negative. In the case of the latter, the expected sign would be positive.

Trade partner takes the value of 1 if the countries have major trading ties and 0 if otherwise. The expected sign of the coefficient is positive; countries are expected to form treaties in order to increase gains from trade, and therefore major trading partners are expected to demonstrate a higher probability of treaty formation.

The total surface area of a country is denoted by the geographic variable '*area of the country*'. The expected sign on the coefficient is negative, since it is expected that smaller countries in general have lesser economic or political power, compared to larger states. Therefore these countries rely more on neighboring countries. This leads to a higher probability for smaller nations to seek the formation of treaties.

Basin area within individual countries is the area of a river basin that flows through a country. It is expected that the sign on this coefficient will be positive, since a larger basin area could indicate a heavier reliance on the river basin itself and thus a higher probability to form treaties. However, there is some ambiguity in this prediction, since much depends upon the relative position of the country (i.e. riparian or upstream positioning) in relation to the participating country with whom a treaty is being formed.

Percentage of the basin area within a country shows the percentage of the total river basin in a particular country. The sign on the coefficient of the variable is expected to be negative, signifying that a country controlling a smaller percentage of a given basin is more likely to seek formal, international measures that would enhance that degree of control. Conversely, a country already controlling the majority of a river basin is less likely to profit from formal apportionment.

The hydrological variable *percentage of water withdrawals associated with agriculture* is expected to be negative, since agricultural economies tend to be developing economies, and are therefore expected to have less bargaining power. These nations are therefore less likely to form treaties, although they might desire the formation of treaties.

The variable *Percentage of water withdrawals for domestic use* is expected to a negative sign as well, because countries that are forced to use the majority of their withdrawals for domestic purposes are generally those countries in which water is relatively scarce. It can therefore be expected that these countries will have a lesser degree of control over a given river basin and will

be less likely to form treaties. Again, this is not to suggest that such countries will not seek the formation of treaties, but rather that they wield insufficient bargaining power to affect treaty formation.

Political similarity shows the similarity in government structure, while '*similarity in language and tradition*' captures the similarity in the norms, traditions, and cultures of the two countries. Coefficients of both of these institutional variables should be negative, because similar governments are expected to have better understandings or international relations with each other, leading to less probability of conflict. In other words, countries with institutional and cultural similarities are generally on good terms, and less in need of formal dispute resolution mechanisms.

Table 1 summarizes the findings of the treaty vs. non-treaty model. The signs on the coefficients of the independent variables are as expected and are significant at different levels. The percentage of trade, for which the expected sign was ambiguous, is negative and significant at the 15% level, suggesting that the majority of international trade may be occurring with non-neighboring countries. Recalling that the expected sign of *basin area within individual countries* was ambiguous, we can now observe that the sign is positive and significant, indicating a heavier reliance on the river basin.

Table 1: Treaty Vs. Non-treaty

Dependent Variable: Treaty = 1 Non-treaty = 0		Number of observations = 256
Independent Variable	Parameter Estimate	Standard Error
intercept	19.581 (4.94)***	8.935
Difference in GDP	-8.099E-7 (3.99)***	4.055E-7
% of trade in individual country	-0.0608 (2.23)*	0.0408
Trade partners (Dummy)	3.463 (3.27)**	1.916
Area of the country	-0.00098 (7.71)****	0.00035
Basin area of individual Country	0.0009 (8.75)****	0.0003
Percent basin area within a country	-0.1088 (3.41)***	0.0589
Percent water withdrawal use for agriculture	-0.1746 (6.17)***	0.070
Percent water withdrawal for domestic use	-0.2851 (4.64)***	0.132
Similarity in Government	-4.5265 (4.22)***	3.303
Similarity in language	-3.5181 (3.21)**	1.964
Likelihood Ratio: 212.3188		
* significant at 15% level		
** significant at 10% level		
*** significant at 5% level		
****significant at 1% level		

V. Empirical Analysis of Treaty Structure

Treaty structure includes provisions for monitoring, information sharing, enforcement, and conflict resolution. Monitoring provisions are often made to include data sharing and surveys. Information sharing builds goodwill and confidence between the countries and enhances agreements. Enforcement mechanisms call for enforcing the provisions of the treaty, while conflict resolution resolves disputes through technical commissions, basin commissions, government officials, or third party intervention.

For this analysis the dependent variable, treaty structure, the sum of the provisions stated in each treaty hence it ranges from 0 to 4. It is zero if none of these provisions are stated in the treaty and 4 if all of these provisions are stated in the treaty. A higher number of provisions in a given treaty would be expected to enhance the structure and sustainability of the treaty. The model used to estimate the factors that contribute to increased structure is as follows:

Treaty Structure = f (Difference in GDP between the countries, Similarity in Government, Non-water Linkages associated with the Treaty, Difference in per capita withdrawal of water between the countries, Percentage of external water flowing into the country)

Difference in GDP between the countries has a negative coefficient and is significant, suggesting that countries with greater disparities in economic power are less likely to agree to a higher degree of contractual stipulations. Thus it may be argued that an economically powerful country may have an advantage in negotiation and bargaining.

Similarity in Government of participating countries is positive, suggesting that the more alike they are in governmental structure, the more likely they are to form a treaty with greater provisions. At first, this may seem to conflict with the results of the empirical analysis of treaty existence, which demonstrated that countries with greater socio-political disparities were less likely to form treaties. However, it must be noted that socio-political factors play different roles at different stages of the negotiation process. In the stage in which countries are still assessing the need for a treaty, socio-political similarity may negate the need for a treaty. Yet in the stage in which countries have already posited the need for a treaty, but are negotiating the structure of that treaty, the data suggests that socio-political similarities enhance the level of contractual explicitness.

Non-water linkages associated with the treaty has a positive coefficient. That is, as non-water linkages in the form of monetary linkages, land, trade or other concessions increase, the probability of forming a treaty with greater provisions also increases.

Difference in per capita withdrawal of water is the per capita withdrawal of fresh water for agricultural, industrial and domestic usage. This has a negative coefficient, suggesting that greater disparities in per capita water use lead to less explicit treaties. This could be because participating countries have difficulty reaching agreements regarding water allocation.

Percentage of external flows is the percentage of the total annual flows accounted for by the flows from other countries into a country. The greater the percentage of foreign flows, the higher

the probability that a treaty with greater provisions will be formed. This is verified by the positive coefficient of the variable.

Table 2: Treaty Structure

Dependent Variable:		
Treaty Structure = 0, 1, 2, 3, 4	Number of observations = 110	
[As measured by aggregating treaty provisions for information sharing, conflict resolution, monitoring, and enforcement; functions as an ordered categorical variable in a probit model]		
Independent Variable	Parameter Estimate	Standard Error
(intercept 1)	1.0681 (9.98)****	0.3380
(intercept 2)	-0.2417 (4.33)***	0.1162
(intercept 3)	-1.2696 (37.79)****	0.2065
(intercept 4)	-1.9068 (66.26)****	0.2342
Difference in GDP of Participating Countries	-0.00001 (8.38)****	0.000002
Similarity between Governmental Systems of Participating Countries (dummy)	0.5904 (4.37)***	0.2823
Non-water Linkages between Participating Countries (dummy)	0.5716 (4.74)***	0.2626
Difference in Per Capita Withdrawals of water in Participating Countries	-0.8976 (2.87)**	0.5294
Percent of External Flows	0.0064 (2.04)*	0.0045
Log likelihood Ratio: -103.847		
* significant at 15% level		
** significant at 10% level		
*** significant at 5% level		
****significant at 1% level		

VI. Conclusion

Externalities, which are often the results of non-explicit contracts, lead to conflicts over river basins. Formal contracts or agreements help to internalize these externalities. However, for full cooperation an explicit agreement with provisions for information sharing, monitoring, enforcement and conflict resolution mechanism is crucial.

This study conducts an empirical analysis of macroeconomic, geological, hydrological, and institutional variable in order to determine factors contributing to treaty existence and treaty structure. The findings of the study suggest that similarities in governmental structure and language decrease the likelihood of treaty formation, and that larger nations, and larger trade bases, or a larger percentage of the basin falling within the are less likely to form treaties. On the other hand, countries are more likely to seek formal agreements if the country with which a bilateral treaty is being considered is a significant trade partner or is similar in terms of economic power, as measured GDP. Further implications of the study are that countries are more likely to seek formal agreements when the river basin in question is relatively large, and that countries depending upon the majority of water withdrawals for agricultural or domestic use are less likely to form treaties due to decreased bargaining power.

Analysis of existing bilateral water treaties suggests that countries with equal economic, political, or bargaining power are more likely to form treaties with greater stipulations or provisions. In other words, explicitness in formal agreements or contracts is likely to be higher between similar countries. Similarity in GDP and governmental systems, the existence of non-water linkages, and higher reliance on external flows increase the likelihood of contractually

explicit treaty structure, while disparities in per capita water use decrease the likelihood of contractually explicit treaties. These findings are in accordance with past research concluding that sustainable cooperation is achieved if there are common goals.

In summary, economic ties and parities between participating countries increase the likelihood of both bilateral water treaty formation and the formation of a treaty with higher degrees of stipulations and provisions despite dissimilarities in geographic, and institutional variables. Different hydrological variables affect treaty existence and structure, while institutional similarities play different roles at different stages of the negotiation process, but economic parity and power consistently lead to greater degrees of cooperation in both formation and structuring of treaties.

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Product of the Transboundary Freshwater Dispute Database, Department of Geosciences, Oregon State University. Additional information about the TFDD can be found at:
<http://www.transboundarywaters.orst.edu>.