

The effectiveness of treaty design in addressing water disputes

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Abstract

We examine the design features of treaties governing international rivers and empirically test their effectiveness in managing water disputes. We expect peaceful conflict management to be more successful and militarized conflict to be less likely in dyadic river claims when riparians share membership in treaties with mechanisms for river basin organizations, information exchange, monitoring, enforcement, and conflict resolution. To test our expectation we analyze a set of diplomatic disagreements over cross-border rivers coded by the Issue Correlates of War project. We combine this database with treaty content data from the Transboundary Freshwater Dispute Database. Empirical analyses suggest that information exchange and enforcement provisions in river treaties are most effective for preventing militarization of river claims and increase the chances that negotiations over river claims successfully resolve the issues at stake. Enforcement provisions also promote third-party dispute settlement attempts and increase the likelihood of compliance with agreements reached. States that share membership in river basin organizations are more likely to experience militarized disputes and less likely to be amenable to third-party dispute settlement. However, the latter states are more likely to reach agreements in peaceful negotiations over their river claims. These findings demonstrate that institutional design influences riparian states' ability to address water disputes.

Keywords

effectiveness of treaty design, international rivers, river treaties, water disputes

Despite the fact that more than two-thirds of our 'blue planet' is covered with water, only 2.5% is freshwater. As populations have grown and nations industrialized, the demand on freshwater has increased at an unsustainable rate. Climate change is projected to aggravate the water shortage in arid regions, such as the Middle East and North Africa (Verner, 2012). These existing shortages resulted in warnings of increasing potential for interstate conflict and tensions over international rivers¹ (United Nations, 2006).

In response to these warnings, experts have been analyzing attempts at cooperation through treaty formation to govern international rivers, such as the Mekong, La Plata, and Jordan (Song & Whittington, 2004; Tir &

Ackerman, 2009; Zawahri & Mitchell, 2011). Treaties do not guarantee a future of stable cooperation because these contracts can solidify power imbalances between states and give the illusion of cooperation (Zeitoun & Mirumachi, 2008). Despite these shortcomings, treaties can provide states with a structured means to organize their affairs and manage disputes (Jacobson & Weiss, 1998). Riparians are more likely to manage their water crises through negotiations in rivers with treaties or commissions compared to rivers without institutionalized systems (Hensel, Mitchell & Sowers, 2006).

Some understandings exist about the forces contributing to treaty formation governing international rivers

¹ An international river is a river shared between two or more states.

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(Tir & Ackerman, 2009; Zawahri & Mitchell, 2011) and the factors influencing treaty design (Conca, Wu & Mei, 2006; Tir & Stinnnett, 2011; Zawahri, Dinar & Nigatu, forthcoming). However, we are uncertain about which design features can help riparians manage water disputes and which features are ineffective (Bernauer & Kalbhenn, 2010). In negotiating treaties, riparians can include several mechanisms that facilitate cooperation, such as establishing river basin organizations (RBOs), monitoring development of the river, conflict resolution mechanisms (CRMs), enforcement mechanisms, and information exchange. We analyze the performance of these various institutional design features to see which provisions are best suited to promote cooperation. For example, the 1960 Indus Waters Treaty required riparians to exchange hydrological information, which decreased tension between them and increased their ability to manage the river (Zawahri, 2009). Water provisions in the Israeli–Jordanian Peace Treaty failed to include mandatory exchange of hydrological information, which decreased the riparians' ability to implement portions of the treaty (Zawahri, 2008).

We find that enforcement provisions have a strong effect on interstate interactions in rivers, reducing the chances for militarized conflict² and increasing the chances for third-party conflict management and resolution of contentious issues. Treaties with information exchange provisions see less militarized conflict among signatories and improved chances for resolving disagreements. RBOs promote agreements when riparians negotiate, but they also increase the chances for militarized conflict. Monitoring and CRMs have little influence on the chances for conflict or cooperation.

We begin by summarizing arguments about institutional design and institutional effectiveness to help identify successful design attributes. Drawing on the neoliberal institutionalist literature, we derive hypotheses about specific design features. We conclude with empirical findings and their implications for states managing interstate river disputes.

² A militarized interstate dispute can involve riparians threatening, displaying, or using military force in response to a dispute over a river. While states might not fight water wars, they have used military means to manage disputes. Examples include a 1998 militarized dispute between Nicaragua and Costa Rica over the San Juan River, a 2000 militarized dispute between Suriname and Guyana on the Corentyne River, and multiple incidents involving riparians on the Jordan (e.g. between Israel and Jordan in 1957, 1959, and 1962–64) and Tigris–Euphrates Rivers (e.g. between Syria and Turkey in 1965, 1987, 1989, and 1996–98).

The rise, role, and function of institutions

As they follow nature's rules and disregard human-made borders, rivers impose complex relationships on riparians because some upstream activities influence the quality and quantity of water available to downstream states. Similarly, downstream activities can influence the upstream state's ability to develop the river within its territory. To minimize the potential losses from these relationships, states need to communicate to exchange hydrological and meteorological data, maintain drainage systems, dredge silt deposits, and distribute their water budget. The more dependent states are on their international river, the more interest they have in cooperation (Zawahri & Mitchell, 2011). Even when riparians are adversaries with a history of conflict, such as India and Pakistan, they have some interest in cooperating to minimize the potential losses from developing an international river. After eight years of negotiations, India and Pakistan eventually signed the Indus Waters Treaty in 1960.

To collaborate, minimize losses, and maintain future cooperation with contracts, states need to reduce their uncertainty about riparian neighbors' compliance and incentives to cheat on agreements. To overcome collective action problems, states need an institution to monitor members' activities, make commitments more credible, sanction defectors, establish the focal points for coordination, lower transaction costs, and gather information (Axelrod & Keohane, 1985; Keohane & Martin, 1995).

An institution's ability to perform these functions is dependent on its capabilities (Koremenos, Lipson & Snidal, 2001; Haftel & Thompson, 2006). Institutional design determines whether an institution can overcome the collective action problems states confront. Existing arguments are inconclusive as to which design features are most critical. Stein (1990: 40) argues that states need an institution that can define cheating 'quite explicitly, ensure that it be observable, and specify verification and monitoring procedures'. Mitchell (1994) suggests that an institution needs to monitor and sanction cheaters to be effective. Chayes & Chayes (1993) contend that CRMs, technical and financial assistance, and transparency are most important for cooperation. Botcheva & Martin (2002) argue that strong monitoring power is important. While the literature identifies a series of institutional design features that promote cooperation, we have little knowledge about the relative importance of these different types of mechanisms for promoting interstate cooperation.

The literature on managing international rivers has also considered the design of institutions for regulating states' interactions in developing the basin but there is

little consensus on which features enable riparians to peacefully address disputes. Giordano, Giordano & Wolf (2005) argue that RBOs, CRMs, flexibility and capability to adjust to change, and clarity of resource distribution and quality control can facilitate cooperation. Schmeier (2013) argues that institutional design features, the nature of the problem structure, and situational structures confronting riparians impact the ability to manage disputes and contribute to the basin's sustainable development. DeStefano et al. (2012) argue that RBOs, CRMs, allocation mechanisms, and variability management can enhance riparians' resilience to climatic variability and avert conflict. Bernauer (1997) calls for an examination of the type of property rights, issues covered, legal framework, financial transfers, monitoring, and openness of the institution.

Empirical analyses of institutional design focus on factors influencing states' interests in investing in institutional design (Stinnett & Tir, 2009; Tir & Stinnett, 2011, 2012). Our study builds upon this literature by identifying the primary design features in river treaties and providing the data to demonstrate their function as facilitators of conflict management. This is an important contribution since researchers discovered that treaties and agreements signed over international rivers tend to establish RBOs that can draw on CRMs (Wolf, 1998; Conca, Wu & Mei, 2006). Moreover, after signing agreements, riparians may confront an increasing number of claims or disputes that need resolution (Brochmann, Hensel & Tir, 2012).

Institutional effectiveness

The neoliberal institutionalist literature views the effectiveness of institutions in terms of problem solving (Underdal, 1992; Victor, Raustiala & Skolnikoff, 1998), whereby an institution is effective when it succeeds in solving the problem that led to its creation. This understanding of effectiveness, when applied to environmental issues, such as ozone depletion, acid rain, over-harvesting of fish stocks, or protection of endangered species, contains an underlying assumption. Given sufficient knowledge, accurate policies, and an effective institution, the problem that led to the creation of the institution can be addressed (Young, 1999).

Yet, sometimes states are confronted with complex relationships that must be managed because they lack a solution or the solution is prohibitively expensive. International rivers represent such a dilemma. Unless a state is able to control the entire river – for example, upstream India invading downstream Pakistan to control the Indus

River or downstream Iraq invading upstream Syria and Turkey to secure access to the Euphrates and Tigris Rivers – a state's reliance on its riparian neighbor cannot be solved, but must be managed. As long as an international border remains constant, states are likely to face continuous conflicts of interests, which require ongoing negotiations. Disputes between riparians may arise over the design, construction, and operation of dams, the construction of industry, the quality and quantity of water, maintaining drainage systems, and managing floods and droughts. Under these conditions, an institution is effective when it is able to assist states in managing a problem that involves continuous conflicts of interests. Therefore, institutional effectiveness in the context of international rivers is best defined in terms of 'process management' (Young, 1999).

Measuring effectiveness

Several operational measures are available to test an institution's effectiveness. Some studies consider the extent to which member states comply with institutional dictates (Chayes & Chayes, 1993; Mitchell, 1994). Others suggest process-tracing states' implementation of treaty commitments (Victor, Raustiala & Skolnikoff, 1998). Jacobson & Weiss (1998) focus on measuring implementation and compliance with an agreement.

Consistent with our attempt to understand the relationship between institutional design and collaboration over complex relationships that must be managed continuously, we consider an institution's ability to manage disputes and facilitate cooperation over a long-term period, which can include deterioration in political relations between member states. Conceding that institutional effectiveness may vary over time (Young, 2011), we argue that if an institution is able to peacefully address riparians' disputes, then one may conclude that specific design features embedded in the institution are effective in facilitating interstate cooperation. Otherwise, an institution that is unable to peacefully address disputes and prevent conflict over a long period is considered an ineffective institution.

The effectiveness of institutional design

Although we are certain that institutional design matters, there is little consensus as to which attributes are most important for collaboration (Koremenos, Lipson & Snidal, 2001; Breitmeier, Young & Zürn, 2006). This lack of consensus produces several problems. First, it minimizes our ability to generate causal mechanisms connecting the existence and operation of institutions to cooperation. Second, if specific design elements serve as the source of institutional effectiveness, then we need to understand which institutional attributes have the greatest impact on

success and why. Finally, our ability to generate policy prescriptions for practitioners negotiating over the creation or modification of institutions is weakened by the absence of knowledge about which institutional attributes are important under which conditions (Young, 1999).

As a step towards remedying some of these shortcomings, we argue that when states are attempting to collaborate in the management of complex relationships, such as managing international rivers, the following institutional attributes may be important for long-term cooperation: RBOs, CRMs, monitoring, enforcement, and exchange of information.

River basin organizations

RBOs, such the Mekong River Commission or the International Commission for the Protection of the Rhine, provide member states with the ability to draw on an institutionalized structure that enables them to meet and communicate directly with one another. Direct communication between members – by phone or email – is necessary to schedule meetings, compile the agenda, and exchange information. Without this institutionalized form of direct communication between members, the ability to perform necessary tasks for managing the river is likely to be compromised or complicated. Institutionalized meetings permit the commissioners to coordinate their activities to dredge the river, install metering stations, or fix an existing metering station.

Another value of RBOs is their ability to provide technical experts, engineers, water resources managers, or an epistemic community an institutionalized mechanism to operate within. The advantage of an epistemic community is its ability to use technical knowledge and shared assumptions to address hydrologically complex problems by identifying negotiating points that can facilitate the resolution of a dispute (Haas, 1992). Examples include the Indus Water Commission and the Israeli–Jordanian Joint Water Commission, both of which are institutions that are operated by engineers with substantial knowledge of the rivers (Zawahri, 2009).

Hypothesis 1: If a pair of states shares membership in one or more treaties that establish RBOs, this should increase the chances for peaceful and successful management of interstate river claims³ and reduce the chances for militarized disputes.

³ A river claim occurs when two or more states' official representatives make statements claiming sovereignty over a specific river that is claimed or administered by another state or contest the use or abuse of a specific international river (Hensel et al., 2008).

Monitoring

To cooperate and minimize losses, states need to reduce their uncertainty about riparian neighbors' compliance and decrease their incentive to cheat. States need the capacity to monitor members' activities to assure compliance with treaty commitments (Keohane & Martin, 1995). The ability to monitor is also important for improving transparency and assisting states in overcoming fear of cheating (Bernauer, 1997). Monitoring is the ability to travel throughout the river system to gather pertinent information on member states' activities. While monitoring can be done remotely or at the border, it remains extremely valuable for states to visit locations inside of neighboring riparians' borders to collect pertinent information. The ability to ask for and be granted permission to inspect any site permits riparians to confirm the accuracy of exchanged data or detect potential cheating. Inspections also provide members with assurances that maintenance work is completed, such as cleaning drainage systems or dredging the river. These inspections permit states (especially developing states such as Syria and Jordan) to collect information on the intentions, preferences, and actions of their riparian neighbors in developing the international river. Such information can involve a neighbor's desire to build additional hydrological infrastructure or expand irrigation systems, which may increase their consumption or control of the river. Through site inspections Pakistan learned that India had modified the design of a dam on a tributary of the Indus basin (Zawahri, 2009). Inspections permit states to ensure that their riparian neighbor's development and consumption plans of the river comply with their agreement.

The 1945 treaty between Paraguay and Argentina over the La Plata included monitoring capacity, as did the multi-lateral 1976 treaty covering the Rhine River. In contrast, the 1985 agreement between Jordan and Syria over the Yarmouk River and the 1987 protocol between Syria and Turkey over the Euphrates River failed to include monitoring mechanisms. The combination of increased upstream consumption by Syrian farmers and climate change substantially decreased the flow of the Yarmouk River, preventing Jordan from filling its 2008 Unity dam, producing tension between the states. As upstream Turkey built dams along the Euphrates River that enabled it to control the timing of the river's flow, Syria lacked the capacity to draw on monitoring mechanisms to enable it to learn about Turkey's progress. This fear of continued upstream developments contributed to conflict. In 1996 and 1998, Turkey and Syria experienced a militarized dispute over upstream Turkey's construction of the Birecik dam.

The ability to draw on monitoring mechanisms enables states to stabilize their expectations about one

another's future behavior, overcome their fear of cheating, and maintain long-term cooperation. This institutional attribute can also change states' incentives to cheat and reduce uncertainty about riparians' intentions.

Hypothesis 2: If a pair of states shares membership in one or more treaties that establish monitoring mechanisms, this should increase the chances for peaceful and successful management of interstate river claims and reduce the chances for militarized disputes.

Conflict resolution mechanisms

To maintain cooperation, states need CRMs to manage disputes that inevitably arise when they are confronted with managing complex relationships (Giordano, Giordano & Wolf, 2005). For instance, if Canada decides to construct a multipurpose dam along a tributary it shares with the United States, the project can affect water quality and quantity and potentially produce conflicts of interest between the states. Canada's interest is to construct the dam and generate the most benefits, while the United States' interest may be set against constructing the project due to the potential harm it can impose. Without a set procedure for steps to be taken to negotiate a settlement to such disputes, states may engage in conflict over the river. However, the existence of CRMs can guide member states through periods of tension and assist them to maintain cooperation. The 1948 multilateral treaty over the Danube Basin included CRMs. The 1960 Indus Waters Treaty between India and Pakistan had elaborate CRMs that have been used successfully to manage water disputes (Zawahri, 2009). The 1994 Israeli–Jordanian Peace Treaty covered their shared water systems, but it failed to provide for CRMs and as the riparians were implementing treaty provisions, they often had to draw on their national leaders to address disputes.

Hypothesis 3: If a pair of states shares membership in one or more treaties that contains provisions for conflict resolution, this should increase the chances for peaceful and successful management of interstate river claims and reduce the chances for militarized disputes.

Enforcement

The problems confronting states attempting to collaborate can be divided into two phases – bargaining and enforcement (Fearon, 1998). According to Koremenos, Lipson & Snidal (2001: 776): 'Enforcement problems refer to the strength of individual actors' incentives to cheat on a potential given agreement or set of rules.'

As the number of collaborating states increases, it becomes more difficult to identify defection from an agreement and to punish defectors, raising fear of free-riding and the desire for rent-seeking, all of which could lead to the collapse of cooperation (Axelrod & Keohane, 1985). Sustaining future cooperation is complicated by the enforcement problem. Iran and Iraq confronted a militarized water dispute in 1980 because their treaty lacked any enforcement mechanisms.

Treaties that contain provisions for enforcement against cheating can improve compliance rates by reducing states' incentives to cheat or decrease the possible rents from cheating. The 1967 treaty between Italy and France over the Roya and the 1984 treaty between Canada and the United States included enforcement mechanisms that involved financial compensation for the harmed parties. The possibility of punishment for cheating and the associated reputational consequences that decrease the prospects for future cooperation should combine to decrease states' incentive to cheat (Henkin, 1979). We expect the presence of enforcement mechanisms in treaties regulating use of international rivers to increase the potential for peacefully addressing water disputes.

Hypothesis 4: If a pair of states shares membership in one or more treaties that contains mechanisms for enforcement, this should increase the chances for peaceful and successful management of interstate river claims and reduce the chances for militarized disputes.

Information exchange

In developing more stable cooperation in a river's management, states require hydrological data. The downstream state depends on its upstream neighbor for collecting and delivering hydrological data; otherwise, it cannot prepare for floods and droughts or generate hydropower, which can lead to social, economic, and political losses. Consider the case of floods. Although they are predictable and essential natural events needed for preserving the soil's fertility, replenishing aquifers, and sustaining a river's ecosystem, floods can inflict substantial losses. The downstream state may minimize the impact of these natural hazards if it receives flood warnings from its upstream neighbors. Flood warnings can provide a grace period between upstream rainfall and the augmentation in a river's flow downstream. This grace period enables the state to make the necessary adjustments – releasing reservoir water from dams, evacuating residents, and transporting food, water, and medicine to the region. Pakistan depends on India for flood warnings and the Indus Waters Treaty assures the delivery of the data.

The downstream state also depends on its upstream neighbor for hydrological data warning of below average precipitation or a drought. As with floods, droughts are normal and regular features of nature, but as people increasingly migrate into drought-prone areas, potential losses increase (Wilhite, 2004). These losses may be minimized if the downstream state receives warnings of insufficient rains, which enable it to implement the necessary policies – drilling wells, reallocating water away from irrigation, and initiating water conservation policies. Without these policy adjustments, states may incur economic and political costs.

In addition to managing natural hazards, the downstream state depends on its upstream neighbor for hydrological data and a regular discharge of the river to generate hydropower. Syria has three major dams along the Euphrates River, which provide 45% of the country's electricity. Due to the lack of hydrological data and the variability in the river's flow, Syria's ability to operate these dams has decreased tremendously (Japan International Cooperation Agency, 2000). Syrian officials noted that they are only able to operate their Euphrates dams at one-third of their capacity (Ka'ddam, 2000). The 1963 treaty over the Rhine covered the sharing of hydrological data, as did the multilateral 1978 accord over the Amazon and the 1982 bilateral treaty between France and Belgium over the Scheldt River.

Despite the benefits of sharing hydrological data among riparians, some governments may perceive this hydrological data as integral to national security (Falkenmark, 1990). When hydrological information is seen as a tightly guarded secret, it is unlikely that states will reveal sufficient data to decrease the cost associated with managing complex relationships or permit the river's integrated development. The failure to exchange hydrological data can increase tensions between riparians.

Hypothesis 5: If a pair of states shares membership in one or more treaties that establishes a provision for sharing hydrological data, this should increase the chances for peaceful and successful management of interstate river claims and reduce the chances for militarized disputes.

Our theory proposes that treaties are more likely to be effective in mitigating riparian conflict if they have RBOs, monitoring, CRMs, enforcement mechanisms, and exchange of information. While we anticipate that each of the mechanisms may improve cooperation and reduce the chances for conflict, we must evaluate the relative success of these various institutional mechanisms through empirical analysis.

Research design

To evaluate our hypotheses, we analyze a set of diplomatic disagreements over cross-border rivers coded by the Issue Correlates of War (ICOW) project (Hensel et al., 2008).⁴ River claims involve disagreements between two or more nation-states over access to or usage of a shared river (Hensel, Mitchell & Sowers, 2006; Brochmann & Hensel, 2009). This may include a downstream state's objection to pollution, excessive irrigation, or the construction of dams by an upstream state. Several notable cases have led to militarized conflict, such as incidents between Israel, Syria, and Jordan in the 1950s and 1960s surrounding attempts by each side to divert water from the Jordan River, and conflict between Turkey, Syria, and Iraq over the construction of dams on the Euphrates. Other disagreements have been managed more peacefully, such as Mexico–USA disagreements over pollution, damming, and water diversion in the Rio Grande, the Colorado River, and their tributaries. We focus on river claims in the regions for which ICOW data are currently available: North and South America, Western Europe, and the Middle East. ICOW records 64 dyadic river claims in these regions from 1900 to 2001, but we include data only from 1945 to 2001 due to temporal limitations of our institutional dataset. We have a total of 538 claim dyad-years for analysis. For example, Argentina and Paraguay have three river claims involving navigational issues on the Paraguay River (1941–67) and water quantity issues due to a diversion project on the Pilcomayo River (1980–83) and a dam (Yacyreta) on the Parana River (1973–79). These three cases contribute a total of 38 cases to the claim dyad-year dataset.

Each of the ICOW river claims is identified based on historical news sources such as the *New York Times*, *Facts on File*, *Keesings*, the *London Times*, Lexis-Nexis Academic Universe, journals, and books on the history of the disputed area. Potential river claims are generated by creating a list of all rivers that cross borders of lengths greater than 100 miles. For each potential claim, the ICOW project uses news sources to construct a chronology of events. Based on this chronology, ICOW codes every attempt to peacefully settle the claim, indicating the years of each settlement attempt, the type of settlement (bilateral negotiations, good offices, inquiry and conciliation, mediation, arbitration, adjudication, and multilateral negotiations), information about third-party actors involved, and

⁴ For detailed documentation about ICOW coding rules, see <http://www.paulhensel.org/icow.html>.

the outcome of each settlement attempt (such as the signing of a treaty resolving the claim and whether the parties comply with agreements reached). Our analyses below employ these additional data from the ICOW dataset, using each peaceful settlement attempt as a unit of analysis. Consider the river claims involving Argentina and Paraguay, which have a total of six peaceful settlement attempts. The two states used bilateral negotiations to try to settle the conflicts involving the Yacyreta Dam (two attempts) and navigational issues on the Paraguay River (three attempts); there was also a multilateral negotiation attempt over the Paraguay River that included Argentina, Paraguay, Bolivia, and Uruguay. For North and South America, Western Europe, and the Middle East, there are a total of 140 peaceful settlement attempts to manage ongoing river claims from 1945 to 2001.

Militarized attempts to settle river issue claims are identified by the ICOW dataset with Version three of the Correlates of War Project's Militarized Interstate Dispute (MID) dataset (Ghosn, Palmer & Bremer, 2004). A MID involves the threat, display, or use of military force between two or more states, including confrontations that reach the level of interstate war (over 1,000 battle deaths). Only MIDs that are directly related to the specific river issue at stake are included by the ICOW project.⁵ We utilize a dummy variable that equals 1 if two riparians experienced a MID in a given dyad claim year (2.97%) and zero otherwise (97.03%). While MIDs may be rare in the dataset because we code the data yearly, 33 of the 64 (51.6%) dyadic river claims in the data experience one or more MIDs.

To capture more general interactions, we also employ an events-based measure of conflict using data from the Conflict and Peace Databank (COPDAB) and the World Events Interaction Survey (WEIS). Both datasets record cooperative and conflictual events between countries by converting events from news stories into an ordinal scale. We use a dataset created by Thyne (2006) that splices the COPDAB and WEIS into a single scale from 1966 to 1992, ranging from -10 (most conflictual) to 8.3 (most cooperative). We convert this information to an ordinal scale that equals 1 if the mean of events interactions in a given dyad-year are negative on the original COPDAB/WEIS scale (representing average hostility) and -1 if the mean of events interactions in a given dyad-year are positive on the original

COPDAB/WEIS scale (representing average cooperation). Zero includes situations where the mean interaction is zero on the COPDAB/WEIS scale or we are missing data. We reversed the direction of the scale with conflict on the higher end to make the data comparable to the MID conflictmeasure. Conflict events occur in 34.4% of the river claim dyad-year cases, an occurrence rate that is over 15 times larger than the frequency of militarized disputes (2.43%) over the contested rivers in the same period (1966–92).

To collect data on treaty commitments and institutional design provisions, we constructed a dyadic treaty dataset that includes information on treaty content, river, and signature states. The treaty data come from the Transboundary Freshwater Dispute Database (TFDD), originally presented in Wolf (1998) and updated since.⁶ We excluded treaties signed before 1945 because they included colonial signatories. We eliminated treaties between states and colonial state on behalf of colonies. We excluded international conventions, but retained treaties between states and political entities in transition to statehood, because they were signatories to the treaty and they participated as self-governing entities in the negotiations (e.g. Palestinian Authority, Eritrea). The data we use in the three regions for which ICOW river data are coded consist of around 100 dyads and over 8,800 treaty dyad-years.

We are interested in five institutional design features: RBOs, monitoring, CRMs, enforcement, and information exchange. These treaty features are coded from the TFDD database using dummy variables for each possible dyad-treaty case. We then expanded the dyadic treaty data into dyad-year format and summed this information by dyad-year, creating a sum of the treaties two states belong to that contain each of the specific provisions. For example, the United States and Canada have up to 12 different treaties that contained information exchange provisions for hydrological data, up to nine treaties with monitoring provisions, and as many as six treaties with CRMs. It is possible for a pair of states to belong to one or more river treaties that do not contain the specified design mechanisms. We did not want to lose the basic information about joint membership in a river treaty; thus we created a summed measure that adds 1 to the original collapsed dyad-year measure and then treats

⁵ It is possible for some of the MIDs to involve multiple issues. In each case, we are able to find evidence linking the river claim issues to the conflict using the MID narratives or news sources.

⁶ See http://www.transboundarywaters.orst.edu/database/interfresh_treatdata.html. We use a dyadic format of the database that includes information on treaty design (Zawahri, Dinar & Nigatu, forthcoming).

years with treaty obligations but not the specific mechanism as a value of 1. A value of zero on our summed indicators suggests that the two states have no river treaties between them in a given year.⁷ The mean dyadic value and range for each of our treaty design variables in the ICOW river claim dyad-year dataset is as follows: RBOs (0.58; 0–3), monitoring (1.36; 0–10), CRMs (1.21; 0–10), enforcement (0.65; 0–3), and information exchange (1.85; 0–14).

We include five control variables in our analyses, drawing upon Hensel, Mitchell & Sowers's (2006) previous analyses of the ICOW dataset. The first measure, issue salience, captures the importance of the contested river and ranges from 0 to 12 (mean = 6.67). This includes information about use of the river for navigation, population and fishing, irrigation, and hydroelectric power. Previous research shows that peaceful and militarized settlement attempts are more likely to occur as the salience of a river issue claim increases (Hensel, Mitchell & Sowers, 2006). The second measure captures the relative capabilities between the two states in the dyad and records the strongest state's dyadic share of the two states' summed CINC scores (ranging from 0.5 for parity to close to 1 for preponderance).⁸ Hensel, Mitchell & Sowers (2006) find that militarized and peaceful settlement attempts are less likely in dyads where the stronger state is much more powerful than the weaker side. In our dyad-year dataset, the mean value is 0.78 and the range is 0.50–0.987. To capture the relationship between a state's capabilities and its position in a river, we also include separate CINC scores for the upstream state (mean = 0.017) and downstream state (mean = 0.019). The final control variable captures the history of militarized conflict in the dyad. Hensel et al. (2008) find that militarized and peaceful settlement attempts are more likely in dyads that have a history of militarized conflict. We use a weighted measure that treats a militarized dispute in the previous year as 1.0 and then drops the weight by 10% going back to ten years prior to the current dyad-year. The average for our sample is 0.17 with a range of 0–3.2. The online appendix provides descriptive statistics for all variables.

⁷ We also tried two different measurement strategies. First, we kept only positive values on the treaty count variables if the treaties contained the specific provisions. And second, we created a dummy variable if the dyad has one or more treaties with the specific provisions. Our results are similar to those reported herein.

⁸ CINC stands for the Composite Index of National Capabilities and captures a state's total global share of demographic, military, and economic power. See <http://www.correlatesofwar.org/>.

Empirical analyses

We begin by analyzing the river claim dyad-year dataset. Table I presents four models: (1) Model 1 has a dependent variable equal to 1 if the states in the dyad experienced a MID over the river in question in a given year and 0 otherwise;⁹ (2) Model 2 has a dependent variable equal to 1 if the states engaged in one or more bilateral negotiations over the river issue in question and 0 otherwise;¹⁰ (3) Model 3 has a dependent variable equal to 1 if the states sought out third-party assistance on one or more occasions including mediation, arbitration, and adjudication; 0 otherwise;¹¹ and (4) Model 4 uses an ordinal dependent variable that equals -1 when states have cooperative relations on average in the COPDAB/WEIS data, 1 when states have conflictual relations, and 0 otherwise.¹² Standard errors are clustered by dyad number to account for interdependence in conflict or cooperation attempts over the same river claim or conflicts involving the same countries but different rivers. Models 1–3 are estimated as a logit model while Model 4 is estimated as an ordered logit model.¹³

In Table I, Model 1, we see that states who share membership in river treaties with information exchange ($p < .01$) and enforcement provisions ($p < .10$) are significantly less likely to experience militarized disputes over their contested river issues relative to states without such treaty commitments. Moving each variable from one standard deviation below the mean to one standard deviation above the mean reduces the chances for militarized disputes from 0.02024 to 0.00007 for information exchange provisions (-28,134%) and from 0.00578 to 0.00023 for enforcement provisions (-2,389%). Information exchange provisions also significantly ($p < .01$) reduce the chances for conflict events (Table I, Model 4). These results are consistent with our theoretical expectations. The more information that states exchange, the fewer social,

⁹ 16 of 538 dyad-years (2.97%) experience militarized disputes.

¹⁰ 78 of 538 dyad-years (13.38%) experience bilateral negotiations.

¹¹ 44 of 538 dyad-years (8.18%) experience third-party settlement attempts.

¹² 85 of 247 dyad-years (34.4%) experience conflict events on average, while 69 dyad-years (27.9%) experience cooperative events.

¹³ The dependent variables in Models 1–3 are dichotomous (0 for no militarized conflict, 1 for militarized conflict); thus we can use a logit model to estimate the probability that ($y = 0$) or ($y = 1$) as a function of a series of independent variables. The model utilizes the log odds or the natural logarithm of the odds ratio (Gujarati, 1995: 554–555). The dependent variable in Model 4 is ordinal (-1 = low, 0 = medium, 1 = high), making the ordinal logit model more appropriate.

Table I. River treaty commitments and management of river claims, dyadic claim data

	Model 1 Militarization	Model 2 Bilateral settlement attempts	Model 3 Third-party settlement attempts	Model 4 Ordinal conflict COPDAB/WEIS
<i>River treaty design features</i>				
River basin organizations (RBOs)	4.372** (1.603)	0.222 (0.399)	-0.913 [†] (0.476)	0.375 (0.575)
Monitoring	0.407 (0.736)	0.421 (0.271)	-0.405 [†] (0.217)	0.982* (0.415)
Conflict resolution (CRMs)	0.241 (0.311)	-0.127 (0.263)	0.033 (0.161)	-0.146 (0.263)
Enforcement	-3.143 [†] (1.687)	0.016 (0.363)	1.710** (0.242)	-0.254 (0.723)
Information exchange	-2.133** (0.728)	-0.224* (0.090)	-0.140* (0.056)	-0.454** (0.159)
<i>Control variables</i>				
Issue salience	0.509* (0.207)	0.080 (0.130)	-0.321 (0.216)	-0.237 (0.171)
Relative capabilities	-6.919** (2.616)	-1.334 (2.935)	-3.645 (2.314)	-10.134** (2.584)
Recent militarized disputes	0.943** (0.285)	0.188 (0.118)	0.327 (0.343)	0.767** (0.290)
Upstream state CINC	-141.640* (65.743)	3.274 (3.328)	7.267** (2.626)	-7.610 (4.708)
Downstream state CINC	-12.752 (75.855)	5.156* (2.292)	14.952** (1.817)	-59.311* (25.258)
Constant	-1.146 (1.599)	-1.767 (2.259)	1.894 [†] (1.018)	
N	538	538	538	247
Wald χ^2	52.430**	387.830**	671.930**	161.290**

Numbers in parentheses are standard errors clustered by dyad; ** $p < 0.01$, * $p < 0.05$, [†] $p < 0.1$.

economic, and political losses that they incur, which can decrease the prospects for interstate tensions. The findings on the positive contribution of enforcement mechanisms in Model 1 are consistent with the general expectation that these mechanisms increase the prospects for maintaining cooperation by decreasing the incentives to cheat (Koremenos, Lipson & Snidal, 2001). The pacifying effect of enforcement mechanisms can also result from increasing states' faith in compliance. However, we see in Table I, Model 4 that enforcement provisions have no significant relationship with lower-level conflict events (although the sign is in the predicted negative direction). Monitoring mechanisms significantly increase ($p < .05$) the chances for average events interactions to be conflictual (Model 4), but have no significant effects on the chances for militarized disputes.

Surprisingly, dyads with treaty memberships that establish one or more RBOs ($p < .01$) are *more* likely to experience militarized conflict (Model 1). Moving this measure from one standard deviation below the

mean to one standard deviation above it increases the chances for a militarized dispute from 0.00019 to 0.00966 (+4,945%). This finding contradicts our expectation and the general belief within the literature on managing international rivers that RBOs have a positive pacifying impact that can mitigate conflict. One possible explanation is that states might select not to use RBOs to manage their international water disputes. Or, if they allow RBOs to operate, riparians might not permit them to meet regularly, which can decrease the positive contribution of these institutions. The bilateral accords between Jordan and Syria illustrate this possibility. Although the 1953 and 1985 accords both supported the establishment of an RBO, this institution was extremely weak. It depended on upper rank government officials to operate and only held meetings when required. The sporadic meetings of these commissioners weakened their ability to manage water disputes between the riparians (Zawahri, 2010). Thus while such treaties can stop high levels

of violence because they are often signed between states that have reasons to disagree, RBOs have difficulty in completely averting conflict.¹⁴

More highly salient ($p < .01$) river claims with a history of militarized conflict ($p < .01$) are more likely to experience militarized disputes as expected. Increasing each variable from one standard deviation below the mean to one standard deviation above the mean increases the risks of disputes by 401% and 612%, respectively. These findings are consistent with the general expectation of the literature about issues of high salience, such as construction of dams (Hensel, 2001; Hensel et al., 2008). Wolf, Yoffe & Giordano (2003) find that the construction of hydrological infrastructures can increase the prospects for militarized conflict between riparians. This was the experience along the Jordan River, when the upstream riparians attempted to divert a tributary and they were confronted by military conflict (Lowi, 1995). The significant influence of a history of militarized conflict on the experience of militarized disputes is consistent with findings by Hensel (2001) and Hensel et al. (2008). A history of conflict also increases the average hostility of dyadic interactions (Model 4, $p < .01$).

Power asymmetry ($p < .01$; -275% first difference effect) in the dyad reduces the chances for militarization (Model 1) and conflict events (Model 4). This can be a consequence of effective deterrence as the weaker riparian is less likely to resort to military means against a hydro-hegemonic neighbor. Consider the Colorado and Rio Grande Rivers, as they flow from the United States into Mexico. Under this highly asymmetric structure, Mexico lacks the incentive to resort to militarized means to manage water disputes with its much stronger riparian neighbor.¹⁵ Examining the CINC scores for the upstream and downstream states separately, we see that militarized disputes are less likely as the upstream state's CINC increases ($p < .05$; -2,539% first difference effect), consistent with the

¹⁴ However, if we analyze the presence of an RBO at the basin level, rather than aggregated at the dyad-year level, we find that basins with an RBO are more likely to experience third-party settlement attempts and agreements reached are more likely to end the overall river claim. See the online appendix.

¹⁵ We also estimated the models in Table I using an alternative measure of states' capabilities: the minimum Gross Domestic Product (GDP) per capita in the dyad. We find similar results for river treaty variables using the GDP measure with a few exceptions: enforcement is no longer significant in Model 1 (militarization) and RBO is no longer significant in Model 3 (third-party attempts).

hydro-hegemony literature. The downstream state's capabilities do not influence the chances of militarized disputes, but dyads are less likely to have hostile event interactions ($p < .05$) if the downstream state is more powerful (Model 4).

Next we examine how institutional features of river treaties influence peaceful attempts to settle river claims. In Table I, Model 2 (logit model), we see that no treaty design features promote bilateral negotiations between states in river claims; information exchange provisions reduce the chances for bilateral talks ($p < .05$; -162%). Dyads with a powerful downstream state are more likely to see bilateral negotiations ($p < .05$; +34.2%). In Model 3 (logit model), we examine the factors that promote third-party settlement attempts of disputes including mediation, arbitration, and adjudication. Enforcement provisions ($p < .01$; +827.9%) have a strong, positive effect on third-party attempts. States attempting to avoid paying the costs incurred with lack of compliance that are included in the enforcement provisions might draw on third parties to mediate their disputes. Riparians belonging to treaties with RBOs ($p < .10$; -194%) are less likely to submit to third-party settlement, which makes some sense if the established organization has a strong mechanism for handling disputes that arise. This finding supports existing expectations that RBOs can help states to address their water disputes (Tir & Stinnett, 2012). Dyads with one or more treaties with monitoring ($p < .10$; -257.7%) or information exchange ($p < .05$; -95.6%) provisions are also less likely to turn to third-party conflict management. On balance, the presence of river treaties with highly institutionalized provisions may reduce the need for external intervention. As the capabilities of the upstream ($p < .01$; +47.3%) and downstream ($p < .01$; +145.4%) states increase, though, third parties are more likely to be involved in attempts to settle river claims.

In Table II, we utilize each peaceful settlement attempt as the unit of analysis. This allows us to capture other aspects of negotiation success, including (1) whether the parties reached an agreement over the river issue claim (Model 1),¹⁶ (2) whether the parties complied with any agreement reached (Model 2),¹⁷ and (3) whether an agreement reached resolved the overall river

¹⁶ Agreements were reached in 72 of the 140 (51.4%) settlement attempts in the 1945–2001 dataset.

¹⁷ Out of the 72 agreements reached, both states complied with the terms of the agreement in 54 cases (75%).

Table II. Peaceful settlement attempts over river issue claims and success rates, 1945–2001

	Model 1	Model 2	Model 3
	Reach agreement	Agreement compliance	Agreement ends river claim
<i>River treaty design features</i>			
River basin organizations (RBOs)	2.471** (0.671)	-0.280 (0.548)	-0.269 (0.325)
Monitoring	0.158 (0.406)	0.214 (0.395)	-0.093 (0.131)
Conflict resolution (CRMs)	0.307 (0.424)	0.294 (0.356)	-0.059 (0.139)
Enforcement	-2.843** (0.743)	-0.017 (1.054)	0.569 [†] (0.303)
Information exchange	-0.072 (0.158)	-0.272 (0.182)	0.419* (0.128)
<i>Control variables</i>			
Upstream state CINC	45.801** (12.289)	34.883* (13.780)	-7.193 (5.315)
Downstream state CINC	-3.957 (2.582)	6.715* (2.076)	-17.329* (5.309)
Constant	-0.401 (0.280)	0.514* (0.225)	-0.960* (0.476)
N	140	71	71
Wald χ^2	197.720**	93.000**	47.740**

Numbers in parentheses are standard errors; ** $p < 0.01$, * $p < 0.05$, [†] $p < 0.10$.

issue claim (Model 3).¹⁸ Given the smaller sample sizes for these analyses, we include only two control variables: the upstream state CINC and the downstream state CINC. We see in Table II, Model 1 that the only institutional variable that improves the chances for two states to reach an agreement in a given negotiation is the presence of a RBO ($p < .01$). This finding is consistent with existing arguments about the role of RBOs in facilitating negotiations over river disputes (Bernauer, 1995; Zawahri, 2009). Increasing the number of treaties with RBO provisions from one standard deviation below the mean to one standard deviation above the mean increases the chances for reaching agreement from 0.2466 to 0.8522 (+246.8%). On the other hand, the presence of one or more treaties with enforcement provisions reduces the chances for any given negotiation to produce an agreement ($p < .01$; -594.5%). Agreements are more likely as the upstream state's capabilities rise ($p < .01$; +145%).

¹⁸ The river issue claim ended in 25 of the 72 agreement cases (34.7%).

In terms of compliance (Table II, Model 2), no institutional treaty provisions improve the chances for both sides to carry out the terms of the agreement, although more powerful upstream and downstream states are more likely to comply with agreements reached ($p < .05$; +40%, upstream, +11% downstream). Yet we see in Table II, Model 3 that information exchange ($p < .01$) and enforcement provisions ($p < .10$) improve the chances that an agreement will resolve the contested river issue. The chances for a river claim to end increase from 0.2459 to 0.4237 (+72.3%) as enforcement provisions are increased from one standard deviation below the mean to one standard deviation above; information exchange provisions increase the chances for a claim resolution by 44.3%. Institutional design features can help states tackle larger water quantity or quality issues. Interestingly, while enforcement provisions might make it harder for riparians to strike accords, any agreements reached are more successful in resolving the overall issues at stake in the river if the parties have treaties with enforcement provisions.

We checked the robustness of our results using several strategies.¹⁹ First, we estimated models using the minimum logged and lagged GDP per capita dyadic score in place of the upstream and downstream CINC measures. Our institutional results are robust to this alternative measure of capabilities. Second, we considered aggregating institutional measures separately for bilateral and multilateral treaties, but found this difficult given the small number of categories for some institutional measures. We instead added a dummy variable for multilateral rivers to capture the general river context and found that our results for the institutional measures were similar. We also found that multilateral rivers see fewer bilateral negotiations and more conflict events. Third, we tried to capture potential endogeneity between conflict in a river and the creation of river treaties with certain institutional features by estimating seemingly unrelated bivariate probit models. We did not find evidence for endogeneity issues in our dataset and our original results hold when controlling for factors that influence the presence of various institutional variables. Fourth, to consider how institutional effects may have varied across time, we added a variable for year to our models. We find similar results, while also observing that the chances for MIDs decrease over time, while bilateral negotiation attempts increase over the time period of our

¹⁹ Details of these results can be found in an online appendix at <http://www.prio.no/jpr/datasets>.

study. Our results also hold if we control for the presence of one or more river treaties at any point in a river claim.

Conclusion

Our study examines the institutional design features of treaties governing international rivers and empirically tests their effectiveness in facilitating cooperation and averting conflict. We argue that peaceful conflict management over diplomatic river issues is more frequent and successful and that militarized disputes are less likely to occur in dyadic river claims when the claimants share membership in treaties with mechanisms for river basin organizations, monitoring, conflict resolution, enforcement, and information exchange. We find that information exchange and enforcement provisions in river treaties are most effective for preventing militarization of contentious river disputes and increase the chances that negotiations over river claims successfully resolve the issues at stake. Enforcement provisions, such as the 1946 agreement between Argentina and Uruguay over the La Plata River that created sanctions for non-compliance, have a particularly strong effect on peaceful and militarized management of river claims and improve the success of negotiations, which is interesting given that these provisions are not commonly used in river treaties.²⁰ This finding is similar to what we see in adjudication in other issue areas (Mitchell & Hensel, 2007). When states go to adjudication, they settle territorial issues in almost every instance, but adjudication is used in less than 10% of over 2,000 total peaceful settlement attempts in the ICOW dataset.

Information exchange is also shown to be an effective rational design strategy, reducing conflict over river issues and improving the chances that states can resolve their river conflicts. States that share membership in treaties that establish RBOs are more likely to reach agreements in peaceful negotiations over river claims, although such dyads are also more likely to experience militarized disputes and they are less amenable to third-party dispute settlement. Monitoring and CRMs provisions have little effect on how riparians manage their interstate disagreements.

The findings from this study are relevant for the management of international rivers today, even though the data end in 2001. As long as riparians continue to develop their international rivers, they will confront a complex relationship that requires negotiations with

neighbors to minimize potential losses. Riparians will need to manage river pollution, negotiate over the construction of hydrological infrastructure, and discuss the quantitative allocation of waters. The disputes, disagreements, and claims that are likely to arise over international rivers today are very similar to disputed issues in the past. Also the primary design features of river treaties are likely to remain constant. The most developed assembly of treaties today – the TFDD dataset containing agreements from 1820 until 2007 – revealed that riparians throughout this period continue to sign treaties that cover hydropower, water allocation, and irrigation. Treaties today are establishing provisions for RBOs, CRMs, enforcement, and information exchange, the same design mechanisms that riparians have traditionally selected to include in their treaties (Giordano et al., 2014). These are also the same design features that are recommended by international relations scholars for maintaining interstate cooperation. Analysts, however, discovered a few new trends that arose in the post-2000 period. River treaties are increasingly including environmental issues and increasingly allowing for the participation of non-state actors (Conca, Wu & Mei, 2006; DeStefano et al., 2012). Despite these changes, our empirical analysis remains relevant for generating policy implications for managing international rivers.

The policy prescriptions from this study can assist international organizations, such as the World Bank, to guide riparians in designing more effective treaties. First, the findings demonstrate that institutional design influences the ability of states to manage an international river peacefully. As a result, riparians and international organizations need to be cautious when designing treaties and learn about effective design features. Second, it is insufficient to establish an RBO to implement treaty commitments because on their own, such commissions do not prevent militarized conflict. Rather, riparians need to be encouraged to provide RBOs with the mechanisms, capabilities, and power needed to avert conflict and assure compliance with treaty dictates. Third, this study revealed that river treaties need to have enforcement mechanisms to prevent militarized conflict and the ability to exchange information. Enforcement encourages states to comply with treaty dictates, while information exchange improves riparians' ability to manage international rivers. These design features also increase the chances that negotiations will resolve river claims. Finally, while the neoliberal institutionalism literature has argued persuasively that monitoring and CRMs are essential to maintaining cooperation and averting defection, we find that they are ineffective in

²⁰ Tir & Stinnett (2011) find that only 7% of TFDD treaties signed between 1950 and 2002 contain enforcement provisions.

assisting riparians in managing their disagreements. Thus policymakers need to invest their time in including enforcement and information exchange provisions in negotiated treaties and less time on designing monitoring and conflict resolution mechanisms.

Replication data

The dataset and do-files for the empirical analyses in this article, along with the online appendix, can be found at <http://www.prio.no/jpr/datasets>.

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