
The Institutional Design of Riparian Treaties: The Role of River Issues

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Abstract

International agreements governing rivers vary considerably in whether they contain institutional provisions for joint monitoring, conflict resolution, enforcement, and/or the delegation of authority to intergovernmental organizations. This article develops an explanation for why some river management treaties include more institutional provisions while others contain fewer, if any. The authors argue that certain types of issues related to river use—water quantity, water quality, and navigation—tend to be difficult to manage and prone to noncompliance. When forming treaties to address these specific issues, states will be more likely to include institutional provisions. The authors test the link between these river use issues and institutional design using a data set of 315 river treaties signed since 1950. The results show that highly contentious issues—and in particular water quantity and navigation—have a greater effect on the institutional design of river treaties than contextual and power politics factors.

Keywords

cooperation, conflict, water, international institutions, transboundary rivers

Population growth, pollution, economic development, and climate change are putting increasing strain on the earth's rivers. The fact that international river basins cover roughly 47 percent of the world's surface (Wolf 2007) suggests that the use

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and development of rivers will likely become an increasingly common source of international tensions. Yet, despite dire predictions of impending “water wars,” accumulated evidence suggests that international cooperation over water resources is the rule, rather than the exception (Bernauer and Kalbhenn 2010).

Emblematic of the trend toward increasing formal cooperation over shared water is the large number of river cooperation agreements that have been signed in the last century. Yet, one important aspect of the growth of river treaties is that their institutional design varies considerably. We refer to treaties that contain institutional features in their design—such as joint monitoring mechanisms, conflict resolution procedures, enforcement provisions, and/or the delegation of authority to intergovernmental organizations—as institutionalized. The 1995 Mekong River agreement, for example, represents a highly institutionalized treaty, with provisions for joint monitoring, a multistage conflict resolution process, and oversight by an intergovernmental organization—the Mekong River Commission. In contrast, several agreements signed in 1998 between Kazakhstan, Kyrgyzstan, and Uzbekistan addressing hydropower on the Syr Darya river are partially institutionalized, in that they specify a process for resolving disputes, but contain no provisions for oversight or governance by a standing organization. Finally, many river treaties contain no institutional provisions at all. We refer to the number of the institutional features an agreement contains as the degree of institutionalization. In this article, we address the question of why the degree of institutionalization varies across river cooperation treaties.

Drawing on an extensive body of literature addressing international institutions and compliance with international law, our theory focuses on the structure of the problem faced by riparian states. Briefly put, we propose that cooperation over certain issues related to river use carries particular problems of uncertainty and enforcement. For river treaties that address water quantity, water quality, or navigation as their primary issue, we hypothesize that—in comparison to treaties primarily addressing other issues, such as flooding and hydropower—the value of institutional governance will be higher. The participating states will therefore be more likely to include institutional provisions in the agreement. We test this hypothesis, along with controls for other geographic, economic, and political factors, using a data set of 315 river treaties, and find strong support for our expectations regarding river use issue area.

These findings have implications for our understanding of patterns of international water cooperation and conflict, the role of international institutions in environmental management, and the broader theoretical literature on the design of international institutions. First, these results help illuminate the relationship between transboundary water resources and international conflict. Empirical evidence demonstrates that nonmilitarized international disputes frequently occur over water (Bernauer and Kalbhenn 2010) and that transboundary rivers are associated with an increased risk of lower level militarized international conflict (Toset, Gleditsch, and Hegre 2000; Furlong, Gleditsch, and Hegre 2006; Gleditsch et al. 2006). At the same

time, no single war has occurred that is directly and unambiguously attributable to water (Wolf 1998; Yoffe and Wolf 1999; Alam 2002; Waterbury 2002). This article suggests one reason why water conflicts stop short of full-scale war. International institutions seem to be more prevalent in river agreements established in situations that are more prone to political conflict and where sustained cooperation would otherwise be difficult. Thus, institutional theory, by highlighting the mechanisms that promote ongoing cooperation, can help us explain the absence of conflict escalation in those situations where it would otherwise be more likely. More generally, our study suggests the need to consider the role of international institutions in studies of conflicts over resources.

Understanding the factors that influence regime design can also inform research into the effectiveness of river management institutions. Much of the recent research on river cooperation focuses on how the design of river management institutions influences their success (Bernauer 1997; Marty 2001; Giordano, Giordano, and Wolf 2005; Dombrowsky 2007; Zawahri 2009a). One analytical assumption that is either implicit or explicit in most of these studies is that the structure of the environmental problem influences regime design (Bernauer 2002), for example, whether the ecological damages are felt equally by all states involved or if the brunt of damages are felt by downstream states. This proposition is also shared by the broader literature on environmental cooperation (Young 1999; Keohane and Levy 1996). Yet, almost no research has evaluated this assumption with any large-N empirical test,¹ leaving the conclusions potentially prone to the issues of case selection and time bias. Our study seeks to close this research gap by providing a rigorous empirical analysis of this basic proposition on a global sample of cases covering the entire post-World War II period.

Finally, these results have implications for the broader study of international institutions, particularly the rational design approach to institutional variation (Koremenos, Lipson, and Snidal 2001). As Mitchell and Keilbach (2001) observe, states have a variety of options to choose from when designing institutions to prevent defection; and as Koremenos, Lipson, and Snidal (2001) note, that choice is far from a settled matter for international relations theory. According to the realist view, institutions have little influence independent of their member states. Therefore, institutional design should not matter and there should be little variation in institutional features. Our results, in contrast, support hypotheses from the rational design approach that posit that the centralization of authority in international institutions is related to uncertainty and enforcement problems. As such, this article provides additional support for this perspective and extends its application into a new issue area.

In the next section, we discuss a series of problems that hinder international cooperation over river use when the issue concerns water quantity, water quality, or navigation. We then outline the ways in which the institutional design of river treaties can address these problems and present our core hypotheses. The article proceeds with a discussion of research design issues and then provides the test of our expectations using a data set of river treaties formed between 1950 and 2002.

Issue Areas and the Problem of International River Cooperation

River cooperation agreements deal with a wide variety of specific issues related to the use of rivers. The Transboundary Freshwater Dispute Database (TFDD) project's International Freshwater Treaties Database has compiled a global list of river treaties and recorded the *primary* issue each treaty addresses.² Due to data availability, we restrict our analysis to treaties signed between 1950 and 2002. While no issue area is dominant in our sample, treaties dealing with water quality represent the modal category and account for about one-fifth of the treaties signed since 1950. Other issues that are frequently addressed by treaties in the TFDD data set are water quantity, hydroelectric power generation, and joint river management. A smaller proportion of agreements are coded as addressing the following issues: the demarcation of a river border, economic development, flood control and relief, infrastructure development, navigation, and technical cooperation and assistance.

Existing empirical evidence suggests that, among the many issues that river treaties address, some are especially difficult to resolve. Several studies based on the Issue Correlates of War (ICOW) project (Hensel, Mitchell, and Sowers 2006; Hensel 2008) provide strong evidence about which river issues tend to be the most conflict-prone. The ICOW project provides a systematic and thorough listing of "river claims"—that is, formal international disputes involving the use of shared rivers—in the Americas, Europe, and Middle East since 1816. According to ICOW, three issue areas are responsible for generating almost all of the river claims. Water quantity claims account for about 67 percent of the yearly river claim observations, water quality claims are present in about 14 percent of the observations, and navigation-related claims account for about 30 percent of the observations.³ Taken together, these three issues account for fully 98 percent of the ICOW river claim observations.^{4,5} The fact that almost all river claims are generated by one of these three issues suggests that—compared to all the other issues that are addressed by river treaties—these three issues are particularly difficult politically.

Based on the evidence that these three issues generate the vast majority of international conflicts over rivers, we expect that water quantity, water quality, and navigation will also be especially difficult to manage under the auspices of a formal international agreement. Although other issues, such as flood control, might present some problems, our theoretical perspective proposes that these three areas are especially difficult. What follows is a discussion of *why* these issues are so problematic. In particular, we focus on the incentive to free ride, the problem of monitoring compliance, uncertainty stemming from natural variability of rivers, and noncompliance due to the lack of technical capacity.

Water Quantity

The problems associated with cooperation over the quantity of river water are not difficult to understand. Water is a basic human need for which there are no

substitutes. An inadequate water supply not only has economic consequences but it also directly affects human survival and therefore can have national security implications. While river water is ultimately renewable, at any given time there is only a fixed supply. One state's consumption of water—for irrigation, drinking water, industrial purposes, and so on—reduces the amount available to other riparian states. For example, Chile's diversion of water from the Luaca River for irrigation starting in the early 1960s decreased the water available downstream in Bolivia. Furthermore, a state's actions could affect the degree to which river water is indeed renewable for other users if the state builds a diversion dam or channel that permanently reduces the downstream river flow.⁶ For example, small-scale diversion has decreased downstream water availability for rivers shared by India and Bangladesh (Nishat and Faisal 2000).

The aim of agreements addressing water quantity is generally to limit total consumption to sustainable levels. Many river treaties do this by allocating withdrawal rates among riparian states or setting a minimum flow that must be maintained. Due to the zero-sum nature of the issue, however, negotiations over a river treaty addressing water quantity are distributional conflicts. In such scenarios, the parties try to secure a greater proportion of the overall amount of water to be withdrawn, complicating the prospects of reaching agreement.

Even when mutual agreement over the allocation of water is reached, these treaties will be vulnerable to noncompliance. Quantity agreements will face an incentive structure that is typical of common pool resources (Ostrom 1990), in which there are private incentives to use the resource beyond sustainable limits, while the costs of overconsumption are publicly shared (Benvenisti 1996). Restraint by other riparian states will tempt cheaters to free ride. Concerns about noncompliance will also be compounded by the problem of identifying noncompliant states. When several states share a river system, it can be difficult to determine which state, or substate actor, is specifically responsible for the overconsumption of water. Dai (2007) observes that many environmental regimes face this problem of the lack of transparency in the source of noncompliance. When the origin of noncompliance is unclear, it is difficult to hold the responsible party accountable, increasing the temptation to cheat and decreasing the ability of riparian states to enforce an agreement.

Water quantity agreements will also face problems of uncertainty that arise not from the behavior of states but from the natural fluctuations in the amount of river water. River flow rates are subject to considerable annual or decennial variability due to seasonal weather patterns, such as rainfall and runoff from snow melt. Seasonal droughts can also decrease the supply of river water while simultaneously increasing demand for it. These patterns are difficult to forecast, particularly for developing countries that lack the needed data gathering capacity (Elhance 2000). Koremenos, Lipson, and Snidal (2001) characterize this general problem as uncertainty over the state (or future states) of the world. The variability of supply makes water quantity agreements a type of incomplete contract (Dombrowsky 2007), in which the participants cannot anticipate all future eventualities. The lack of data makes coordinating river development projects difficult because of the long time

horizons and asset specificity of water infrastructure investments (Dombrowsky 2007). Seasonal variability of the Ganges system, for example, is a major concern affecting cooperation between India and Bangladesh (Nishat and Faisal 2000). A key part of this problem has been the lack of reliable information on seasonal flow patterns, inhibiting the ability to forecast flooding.

Hydrological uncertainty makes water allocation agreements both difficult to negotiate and maintain. Under uncertain conditions, it is not easy to design optimal solutions to water-sharing problems (Elhance 2000). Without the ability to make long-range forecasts, states may be reluctant to pay for investments into water supply infrastructure. When unanticipated circumstances in the level of river flows arise, one or more parties may desire to renegotiate or abrogate an agreement. Kilgour and Dinar (2001) observe that agreements which specify a fixed supply often endure only until the first drought occurs. In 1999, for example, drought reduced Israel's ability to deliver water to Jordan under the terms of the 1994 peace agreement (Kilgour and Dinar 2001). In sum, water quantity cooperation presents serious, multifaceted challenges.

Water Quality

Aside from the availability of water, the quality of water can necessitate formal cooperation. A prime example is the 1976 Convention on the Protection of the Rhine, for which reducing the high levels of chemical pollution coming from French and German industry was the primary focus. The quality of river water can be improved through better management practices, such as the protection of wetlands and watersheds, the minimization of soil erosion and agricultural runoff, and wastewater treatment. In addition, improvements in the quality of river water can increase the total quantity of water available for consumption (Sadoff and Grey 2002).

River treaties addressing the issue of water quality may face strategic problems similar to those surrounding water quantity agreements. Pollution abatement can be costly, which can lead to distributional problems when states try to minimize their share of the overall costs of protecting water quality. The projected cost of reducing chloride pollution to target levels was the primary factor behind France's refusal to implement an initial agreement on Rhine water quality proposed in 1972 (LeMarquand 1977). Even when the parties agree to water quality target levels, the same incentives to cheat that plague quantity agreements can also tempt states to avoid paying the economic costs of environmental regulation and pollution abatement. Environmental efforts by some riparian states may simply lead others to free ride, enjoying the benefits of improved water quality but paying less of the costs.

As with water quantity, monitoring and enforcing water quality cooperation involves problems of observing both the sources and the effects of noncompliance. River pollution can have many individual sources, making it difficult to identify the actor (or actors) responsible. In addition, the effects of river pollution are often delayed and latent, in which case the environmental and health consequences for the

victims cannot be unambiguously traced to the quality of the river water. In these circumstances, detecting noncompliance can be costly, because the victims will not be able to serve as low-cost monitors of cooperation (Dai 2007).

Aside from the possibility of calculated cheating, parties may fail to comply with water quality agreements due to limits on the technical or economic capacity of the parties. The managerial approach (Chayes and Chayes 1995) contends that states have a natural tendency to comply with their treaty obligations, and when they fail to do so it is because they do not have the economic or technical resources to properly implement a policy. The infrastructure needed to manage water quality often requires large capital investments (Dombrowsky 2007). Failure to meet target levels of water quality may occur simply because of a lack of the economic resources to make necessary investments. In addition, protecting river water quality requires regulating the actions of a multitude of substate actors that are responsible for industrial pollution, municipal waste, and agricultural runoff. Failure to implement an agreement protecting river water quality may often occur because of a state's understaffed and underfunded enforcement bureaucracy. The lack of technical resources and trained experts is particularly acute in developing countries (Elhance 2000).

Navigation

International agreements addressing navigation are one of the oldest forms of river cooperation, dating back over a thousand years on the Rhine river, for example (Sadoff and Grey 2002).⁷ While older navigation treaties mostly concerned the issue of free passage, modern era agreements often broaden this scope to include technical issues dealing with maintaining and improving waterways, prohibiting water diversion in order to assure navigable depths, building or maintaining lock and dam systems, or otherwise addressing some aspect of river hydrology. For example, the 1952 treaty between East Germany and Poland over navigation of their shared border rivers specifically obligates the parties to maintain navigable depths by performing dredging operations and not building infrastructure that could adversely affect water levels. More recent navigation treaties also introduce environmental concerns, where water quality issues feature prominently. For instance, in addition to the freedom of navigation and preparation of the river for navigation (e.g., dredging to increase the water depth) stipulations, the 2002 Sava River Treaty among Slovenia, Croatia, and Bosnia addresses the issue of water quality needed to maintain the health of the river ecosystem.

In addressing contemporary navigation issues (see note 7), we focus on problems related to river hydrology, water depth/quantity, and pollution. In dealing with these concerns, navigation agreements confront problems somewhat similar to the issues discussed in the above sections but also introduce additional concerns. Keeping rivers navigable requires regular maintenance and substantial financial expenditures. River channels must be kept open in order to be navigable, through, for example, dredging. Locks, bridges, and dams may have to be constructed and must be

maintained as well. Failure to pay these costs can jeopardize safety and decrease the commercial value of a river as a means of transport. As with the costs associated with quantity and quality agreements, there will be distributional problems regarding how these costs will be shared among riparian neighbors. Rules governing navigation can also affect water quality, as excessive shipping and poor environmental standards for ships can lead to water pollution. There are temptations to cheat (e.g., avoid upgrading the fleet to higher environmental standards in order to protect profit margins) and costs associated with monitoring water quality, cleanup, and enforcement of environmental standards. Given the vast amount of shipping on larger international rivers, these issues can surface frequently and result in disagreements over who is to blame, who should shoulder the costs, and how the problems will be addressed.

Furthermore, navigation requires a minimum quantity of river water, which can be difficult to meet. Due to continuing population and economic growth, riparian countries are coming under increasing pressure to divert ever more river water for human, crop irrigation, and industrial use. Furthermore, effects of climate change may lead to droughts or wild seasonal variations in rainfall. In addition to adversely affecting water levels for navigation directly, both of these problems may push riparian states to rely on the transboundary river water even more to satisfy their needs—which will indirectly interfere with navigation and raise tensions.⁸ Thus, these scenarios are ripe for blame games over falling water levels and for political controversies over which side should forego more river water in order to maintain the navigability of the river.

In sum, a host of issues can adversely affect the ability of states to use shared rivers for navigation, both directly and indirectly, creating a structure of interactions prone to generating political conflicts. In that sense, navigation is similar to the other two river-related issues that can be sources of serious conflict discussed in preceding sections. But what sets navigation as an issue at least somewhat apart is the relative ease with which the related controversies may escalate. Restricting navigation, by seizing vessels and denying transit, is one easily employed means of retaliation. Unfortunately, counterretaliation is about as straightforward, setting the fledgling conflict on a path of spiraling escalation. So these seemingly mundane conflicts over issues such as waterway maintenance have the ability to quickly escalate and become highly politicized. As argued below, institutionalized treaties can help deal with these scenarios by preventing navigation-related controversies from emerging in the first place (e.g., monitoring dredging operations and water levels) or by defusing problematic situations (e.g., utilizing conflict resolution mechanisms to provide a forum for grievances to be aired without having to resort to boat seizures or determining which side needs to dredge and how much), thereby reducing the chances of conflict escalation.

Treaty Institutions and River Cooperation

When negotiating river treaties, the signatories may anticipate the corresponding difficulties with implementation and compliance. Adding institutional provisions

to a treaty is one strategy for dealing with these problems. We discuss four common institutional features present in river treaties: monitoring, enforcement, conflict management, and the delegation of authority to intergovernmental organizations.

Monitoring

About 47 percent of the river treaties in our sample specify a formal process for monitoring shared rivers.⁹ Joint monitoring institutions can provide a centralized and standardized source of data on river conditions, such as water volume, flow rates, river traffic, and pollution levels. This can contribute to the effectiveness of river agreements in a variety of ways.

First and foremost, monitoring can help alleviate compliance problems that are likely to threaten agreements addressing water quality and quantity, and, to a lesser extent, navigation. Given the complexities of transboundary river systems, assessing treaty compliance requires highly specialized and detailed data. Dai (2007) explains that a centralized international institution for monitoring compliance is often necessary when the source of noncompliance is difficult to observe, as is often the case for water quantity and quality. Treaties that contain monitoring provisions can promote enforcement by minimizing the probability that violations will go undetected. In some cases, cheating will be deterred because of the likelihood of detection. In other cases, the information will help reassure the treaty participants that the signatories are complying with treaty provisions. Monitoring hydrological development projects in the Indus river system by the Permanent Indus Commission (PIC), for example, has eased fears of cheating between India and Pakistan and helped promote compliance with the 1960 Indus Waters Treaty (Zawahri 2009a).

River monitoring institutions can also help address uncertainty that originates from the natural hydrological variability of rivers. A problem that plagues the management of international rivers is simply the lack of necessary data; this is especially true for developing countries (Elhance 2000). Centralized monitoring is a way to address the capacity issue connected to the costs of data collection and the lack of financial resources and technical expertise. As Abbott and Snidal (1998) observe, the centralized nature of intergovernmental organizations increases the efficiency of both the collection and the dissemination of technical information. When monitoring is done through an intergovernmental body or joint commission, the costs will be shared by the member states, alleviating some of the problems stemming from the lack of resources and technical capacity.

A final benefit of joint monitoring provisions in river treaties is the perceived political independence of international institutions. States often keep river data classified on national security grounds (Hamner and Wolf 1998; Elhance 2000). Joint data gathering, however, can alleviate disputes over water data and prevent broader conflict (Bernauer and Kalbhenn 2010). Data collection done through an international institution is especially advantageous in this context because international organizations are more likely to be perceived as neutral providers of information

(Abbott and Snidal 1998). More broadly, the political independence of these institutions can help facilitate communication and cooperation during periods when other diplomatic channels might be cut off due to international disputes.

Conflict Resolution Mechanisms

Approximately 35 percent of our sample of river agreements specify procedures for the management of disputes between signatory states. The exact provisions tend to vary. At one end of the spectrum are provisions for direct negotiations. The Permanent Indus Commission, for example, is responsible for resolving disputes between India and Pakistan over the implementation of the Indus Waters Treaty. Disputes are managed primarily through regular meetings of the engineers and officials that make up the two national sections of the commission (Zawahri 2009b). At the other end of the spectrum are conflict resolution mechanisms that mandate mediation or adjudication by a third party, including existing international institutions. For example, Hungary and Slovakia have also taken a dispute over a water project on the Danube to the International Court of Justice (ICJ).

A formal procedure for resolving disagreements can improve the prospects of treaty compliance via several different channels. Because they provide for the evaluation of noncompliance in a public forum, judicial dispute resolution mechanisms can enhance the reputational costs of violating an agreement (Abbott and Snidal 2000). Conflict resolution in the form of third-party mediation or adjudication may also help neutralize domestic political opposition that can make compliance difficult. By moving a disagreement to an international forum, a government can provide political cover by removing the issue from its direct control. For example, Simmons (1999, 2002) and Allee and Huth (2006) find that states tend to submit territorial disputes to international adjudication in order to overcome the domestic political pressure that makes it difficult to achieve compromise through direct negotiations. Hansen, Mitchell, and Nemeth (2008) find that mediation of territorial, maritime, and river disputes by international organizations tends to be more successful at producing an agreement between the parties if the organization is highly institutionalized. Similarly, Mitchell and Hensel (2007) find that compliance with agreements to settle a dispute is especially high in cases of binding adjudication by third parties.

Aside from addressing conflicts over river use, dispute resolution procedures are also a means of adapting an agreement to uncertain circumstances. The management of international rivers is hampered by natural uncertainty over water conditions and a lack of data; this is particularly problematic for treaties addressing not only water quantity and quality but also for navigation agreements in light of the expected variability in rainfall that would in turn affect water levels needed for navigation. Forming flexible or ambiguous water sharing agreements may be a strategy for coping with this uncertainty (Fischhendler 2008a). A flexible agreement will allow the parties to adapt to changing environmental conditions without having to renegotiate

the agreement. Of course, imprecise agreements can lead to disputes when conflicting interpretations arise (Fischhendler 2008b). Thus, provisions for third-party adjudication will be advantageous under conditions of hydrological uncertainty, by allowing the parties to form flexible agreements while minimizing the risks that flexibility will contribute to noncompliance. Koremenos (2007) advances a similar argument that is supported in a large sample of international agreements.

Enforcement Provisions

A small number (about 7 percent) of river treaties in our sample contain provisions specifying how the agreement will be enforced. These provisions typically delegate enforcement authority to a council (Wolf 1998), rather than explicitly authorizing sanctions. Enforcement procedures can help deter cheating by raising the visibility of violating an agreement and thus increase the damage of cheating to a state's reputation (Keohane 1984). This will help support the decentralized self-enforcement of the agreement by the parties. Because of the higher risks of cheating, enforcement provisions will be particularly important for treaties dealing with water quantity, water quality, and navigation.

In the event of noncompliance, enforcement procedures can also increase the effectiveness of sanctioning. Formal rules authorizing enforcement can reduce the transaction costs of sanctioning (Benvenisti 1996) and enhance sanctions' effectiveness by making them more acceptable politically. Sanctions that are implemented according to the rules laid out in an international agreement will be seen as more legitimate than unilateral efforts. When they are seen as legitimate, sanctions will be less likely to damage relations between the parties in other issue areas. For example, in Slovakia's dispute with Hungary over the Danube, rulings by the ICJ helped stop the dispute from escalating and preserved overall relations between the parties (McCaffrey 2003).

Intergovernmental Organizations

Finally, a number of river treaties (about 35 percent of our sample) establish intergovernmental organizations or delegate oversight to existing organizations. These bodies can vary widely in their structure and functions (Dombrowsky 2007). At one end of the spectrum are complex organizations with permanent secretariats and decision-making powers, such as the Mekong River Commission. At the other end are technical committees composed of engineers and other policy experts from the signatory states; a prime example is the Joint Water Committee created as part of the 1994 Israel–Jordan peace treaty, which is responsible for implementing provisions related to water sharing, storage, and quality for the Jordan and Yarmouk rivers (Haddadin 2000).

Oversight by intergovernmental organizations can help promote compliance with river treaties via several different mechanisms. In particular, formal organizations

will help support the functions of the other treaty institutions discussed above. By providing a centralized forum for disseminating information, they help support the monitoring of treaty compliance. In the event that cheating is detected, intergovernmental bodies, as venues for communication and diplomacy, will increase the reputational consequences of noncompliance. Should punishment be necessary, intergovernmental organizations can also enhance the effectiveness of sanctions by improving the credibility of the leading state (Martin 1993) and centralizing the sanctions effort (Abbott and Snidal 1998).

Furthermore, intergovernmental bodies can help address uncertainty stemming from the natural variability of river environments and the resulting problem of incomplete contracting. Commissions composed of scientific experts will help to reduce natural and hydrological uncertainty by sharing technical and environmental data. In the event that a treaty must be modified in response to changing environmental conditions, intergovernmental bodies can facilitate diplomacy and negotiation. This is also true for the small number of treaty organizations that possess rule-making authority. In fact, one reason for delegating rule-making authority to intergovernmental bodies is to provide a way for parties to clarify imprecise rules (Abbott and Snidal 2000).

Finally, intergovernmental organizations can help deal with compliance problems for treaties in which the parties lack the capacity necessary to address water quality and quantity issues or maintain navigation, in light of problems such as seasonal rainfall variability, droughts, or increasing diversion of water for irrigation or industrial use given the demands of a growing population or economy. Technical commissions composed of engineers and water policy officials can provide a central administrative structure. By pooling the associated costs and preventing the duplication of national efforts, intergovernmental bodies will increase the efficiency of scientific and technical activities (Abbott and Snidal 1998). River basin organizations can also address limits on economic capacity by attracting funds and coordinating the financing of river development projects. For example, the Mekong River regime, has helped attract funding for water projects from the World Bank (Browder 2000).

River Treaty Design and Institutionalization

Despite the potential benefits to river management that international institutions can provide, establishing institutions is not without costs. States may resist delegating authority to international institutions because of the contracting costs that come with negotiating a more detailed agreement and establishing new international bodies (Abbott and Snidal 2000). These costs must be paid up front, before any of the benefits of institutions are realized. In addition, states may fear the loss of policy autonomy, so-called sovereignty costs. These costs often stem from a normative or ideological attachment to national sovereignty (Kahler 2000). Zawahri (2009a) notes that states often resist integrated river basin management because it can impinge on political sovereignty. States may therefore resist institutional oversight

Table 1. Summary of Main Expectations and Findings

Main Expectations	Supported?
Highly contentious issues related to river use are associated with a higher level of river treaty institutionalization	Yes
Water quantity issue is associated with a higher level of river treaty institutionalization	Yes
Water quality issue is associated with a higher level of river treaty institutionalization	No
Navigation issue is associated with a higher level of river treaty institutionalization	Yes

not for strict utilitarian reasons but because they simply reject the delegation of authority to international organizations on principle. Thus, states will tend to resist the dilution of national sovereignty and the financial and opportunity costs of establishing new institutions *unless* they have a compelling reason to do otherwise.

As explained above, we expect that the benefits of institutional governance will be particularly large for treaties that address water quantity, quality, and navigation issues—as opposed to treaties dealing primarily with issues such as hydroelectric production, flooding, and so on. Our theory proposes that these three issues present states with a multifaceted set of problems that cannot be easily resolved with just simple coordination or soft law. The implication is that, when negotiating treaties in which the central issue is water quantity, water quality, or navigation, states will design agreements that include more institutional features. Our expectation follows the claim of the rational design perspective that international institutions will be more centralized the greater the severity of the enforcement problem (Koremenos, Lipson, and Snidal 2001). Even though we have discussed several institutional provisions separately, our primary interest is in the overall institutional design of river treaties. Thus, the dependent variable in our analysis, the degree of institutionalization, is the total number of institutional provisions a treaty contains. The specific hypotheses are summarized in Table 1.

Research Design and Measurement

Our unit of analysis for this study is the river treaty, as identified by the International Freshwater Treaties data set provided by the Transboundary Freshwater Dispute Database (TFDD) project. We include all the agreements that were signed between 1950 and 2002.¹⁰ After some cases were dropped due to missing data, we are left with a sample of 315 agreements.

Dependent Variable: River Treaty Institutionalization

The dependent variable is an additive index composed of the following institutional features potentially contained in each agreement: monitoring, enforcement, conflict

resolution, and international organization. The first three components are variables recorded in the International Freshwater Treaties Database. International organization was identified if the treaty created a new international organization to oversee the agreement or delegated authority to an existing organization, based on information in the comments section of the database. Each component is scored 0 or 1, and then all four component variables are summed for each agreement. This produces a scale of institutionalization ranging from 0 to 4, with a mean of 1.25 and a median score of 1 in our sample. We only make the weak assumption that the final index is ordered, rather than an interval scale. Additionally, by weighting each component equally, we do not impose any assumptions about the value of one specific institution over another. Given the nature of the dependent variable, the method of analysis used is an ordered probit regression, which only requires that the categories of the dependent variable are rank ordered.

Issue Area

The variables dealing with the issue areas are obtained from TFDD's International Freshwater Treaties database that records the primary issue a treaty addresses.¹¹ Using this coding scheme, we include dummy variables for whether the central issue of a treaty is Water Quantity, Water Quality, or Navigation. The frequencies of these three variables are about 18 percent, 22 percent, and 3 percent, respectively. We also create a combined Highly Contentious Issue variable, which is coded 1 when any of these is the primary issue for the treaty. Forty three percent of the treaties thus receive a Highly Contentious Issue designation, while 57 percent of the treaties represent the residual/comparison category.

Control Variables

We control for several factors suggested by previous research on both river management and international cooperation in general, which deal with geographic, economic, political, and security-related issues. The measurement of these variables is somewhat complex because the unit of analysis is the treaty, but many of the covariates are based on characteristics that are observed at the national or dyadic level. We thus start by averaging the value of each variable over five-year period prior to and including the year in which the agreement was signed. This is done in order to capture the value of the variables during the period in which the negotiations are being conducted and because decision makers will likely base their decisions on recent history. After averaging each variable temporally, we aggregate the data spatially across the treaty partners as specified below.

Number of shared rivers. States sharing multiple rivers face a greater number of potential problems, as each river could be the basis for a dispute or source of disagreement. This effect may create an incentive to establish stronger institutional oversight, in order to prevent noncompliance from snowballing. Furthermore, more rivers might bring increasing returns to scale for institutionalization. Tøset,

Gleditsch, and Hegre (2000) provide data for the number of rivers that the riparian neighbors have in common and we use the mean number of shared rivers for all the contiguous dyads that make up each agreement.¹²

Flow pattern. Previous research suggests that an upstream/downstream relationship between riparian states might inhibit cooperation. Such situations create asymmetric externalities, in which the downstream state pays for more of the costs of the upstream state's behavior. Institutional solutions are not impossible in these situations, but they often require broadening the scope of an agreement through issue linkage (Mitchell and Keilbach 2001; Dinar 2006). This will increase the total cost of institutions and could discourage the institutionalization of river treaties, especially for upstream states. The data on river flow pattern come from Tostet, Gleditsch, and Hegre (2000). We use proportion of upstream/downstream dyads for all the contiguous dyads that make up each agreement.

Economic development. The level of economic development may affect the institutionalization of river treaties in two ways. First, rich states possess resources to develop modern technologies for river use and protection (Elhance 2000), which can reduce the extra benefits that may be derived from deeply institutionalized river management. Poor countries, on the other hand, will be less equipped to deal with the problems facing their rivers alone and will need to maintain effective international cooperation, giving them an incentive to promote stronger institutions. In addition, following the general logic of Chayes and Chayes (1995), countries need technical and bureaucratic capacity to effectively comply with international agreements. In the context of river cooperation, poor countries have less capacity to implement environmental protection agreements by themselves. Institutions can increase state capacity by pooling scarce resources and sharing the costs and benefits of technical knowledge and expertise (Abbott and Snidal 1998). The expectation that state interests in riparian cooperation diverge based on their levels of development is supported by the findings reported in Gleditsch et al. (2006) and Tir and Ackerman (2009). The influence of economic development is measured by the highest gross domestic product per capita of all the parties to an agreement, as recorded in Gleditsch (2002). The most developed state serves as a bellwether for the capacity available among the parties. As the most developed state becomes poorer, institutions are needed as a substitute source of technical and economic capacity.¹³

Trade interdependence. Economic interdependence provides a context in which states might be more amenable to institutionalized river cooperation. Elhance (2000) observes that transboundary water courses are one element in a web of economic, environmental, and political interdependencies and that broad patterns of economic interdependence create conditions conducive to river cooperation. When states trust each other, they may be more willing to accept the sovereignty costs that come from delegating authority to international institutions. Trade interdependence is measured by the ratio of trade between all agreement members to the total trade members engage in with the world. Bilateral trade statistics are taken from Gleditsch (2002).

Democracy. Democracies have been shown to have a special relationship with each other that they do not share with authoritarian countries (Russett and Oneal 2001). Empirical evidence also suggests that democracies favor membership in international organizations shared with other democracies (Mansfield and Pevehouse 2006). Thus, democratic states might be more willing to accept some limits to sovereignty imposed by strong river treaty institutions if the membership is made up of other democracies. Regime type is measured using Polity IV's (Marshall and Jaggers 2006) net regime score. Based on the weak link logic that joint democracy is critical for trust, we use the lowest regime score for the parties.¹⁴

Alliances. We control for the extent to which the alliance patterns of the states negotiating the treaty are congruent. Greater similarity may indicate shared interests and greater levels of trust. This can in turn result in attainment of additional common objectives, including more institutionalized river cooperation. We use Signorino and Ritter's (1999) *S* score of foreign policy similarity based on military alliance portfolios, and rely on the mean *S* score for all the dyads in the agreement.

Previous military conflict. Adversarial relationships accompanied by relative gains concerns are identified by Lowi (1995) as the key culprits that keep river cooperation at rudimentary levels in the Middle East. We therefore control for the history of militarized conflict among riparian states entering a treaty. The variable is measured as the proportion of within-treaty dyads that have experienced militarized interstate disputes in the previous five years, based on the Correlates of War MID data (Ghosn, Palmer, and Bremer 2004).

Power. The realist perspective maintains that institutions are created by powerful states to further their own interests (Mearsheimer 1995), in which case we might see powerful states promoting institutionalization. Alternately, a powerful state may force an agreement in which the proposed distribution of the river resources mirrors the distribution of power. In this case, there will be little temptation to violate the agreement and little need to establish new institutions to enforce it. To control for these possibilities, we include a power concentration variable, measured as the ratio of the most powerful state's capabilities to the total capabilities of all the parties, based on the Correlates of War Material Capabilities composite index (Singer, Bremer, and Stuckey 1972).

Results and Discussion

Model 1 in Table 2 presents the results of our analysis with the three highly contentious issues combined into a single indicator. The issue coefficient is positive and significant. This is strongly supportive of our expectation that, for treaties that address these difficult issues, policy makers will have an incentive to delegate authority to centralized international institutions. Acting on these incentives, policy makers will design treaties that include some combination of institutional provisions for monitoring, enforcement, conflict resolution, and the creation of intergovernmental organizations. The expected benefits of institutionalization for treaty

Table 2. Ordered Probit Estimates of the Institutionalization of River Treaties

Variable	Model 1	Model 2
Highly Contentious Issue	.338** (.130)	
Water Quantity		.452** (.166)
Water Quality		.147 (.179)
Navigation		.686* (.381)
Number of Common Rivers	-.007 (.020)	-.004 (.020)
Up/Downstream Relationship	-.404* (.180)	-.432** (.181)
Level of Econ. Development	-.00002*(.00001)	-.00001 (.00001)
Trade Interdependence	3.576* (1.718)	3.620* (1.719)
Democracy	-.017 (.011)	-.015 (.011)
Foreign Policy Similarity	.762 (.498)	.822* (.502)
Militarized Interstate Disputes	-.028 (.063)	-.041 (.064)
Power Concentration	.050 (.364)	.028 (.364)
Intercept 1	-.207	-.151
Intercept 2	.763	.825
Intercept 3	1.626	1.692
Intercept 4	2.693	2.759
N	315	315
Chi-squared (df)	19.35** (9)	22.37** (11)

Note: Cell entries report ordered probit coefficients, standard errors (in parentheses), and one-tailed significance levels: ** $p < .01$; * $p < .05$.

implementation and the management of common rivers will make states more willing to pay the costs of institutionalization. This finding is not only supportive of our own expectations but also of the rational design approach, which posits that the nature of cooperation problems will condition the design of international institutions. In addition, this result clashes with realist expectations that institutional design should be unrelated to influences other than the relative power distribution and that states are generally unwilling to cede sovereignty—especially in exchange for benefits over what are perceived to be low politics issues. Our findings therefore have bearing on important and long-standing theoretical debates found in the broader international relations literature.

In model 2, the effects of the three highly contentious issues are examined separately. While the coefficients for all three issue variables have the expected signs, only the water quantity and navigation variables are significant. These results are also highly supportive of our expectations and provide more nuanced evidence about the particular issue areas that drive treaty design. Although the null finding for the water quality variable is contrary to our initial expectations, it can be attributed to the following observations. First, water quality may be easier to address on a unilateral basis than quantity or navigation, provided that states possess adequate technology for wastewater treatment and pollution abatement. Furthermore, polluted river water can still be used for some industrial purposes, such as the cooling of nuclear reactors or hydroelectric power generation. Both of these observations suggest that

the issue of water quality may not be as problematic as it may first appear. This makes the lack of compliance with treaties that regulate river water quality less important than, for example, the diversion of river water, in which case other users have little ability to address the problem unilaterally. Indeed, the ICOW data (Hensel 2008) suggest that water quality is the least problematic of the three issues in generating claims over rivers: it is responsible for only about 14 percent of the claim observations. Although water quality is the source of some interstate disagreements, these disputes are likely to be much less salient than those arising from other issues. Thus, policy makers may not feel the same need to institutionalize treaties that deal with water quality. The main findings are summarized in the right-hand column of Table 1.

Turning to the control variables, we find mixed results. Starting with the geographic variables, the number of rivers the riparian states have in common is insignificant. The results confirm the expectation that upstream/downstream relationships tend to discourage treaty institutionalization. Concerning the economic variables, the economic development coefficient is negative, as expected, but barely significant in model 1 and insignificant in model 2. The negative sign is consistent with the expectation that treaties led by wealthier countries tend to include fewer institutional provisions. This result is also consistent with previous findings that development reduces chances of river cooperation (Gleditsch et al. 2006; Tir and Ackerman 2009) and extends it into the domain of treaty design. Furthermore, we find that trade among parties to an agreement significantly increases the level of institutionalization. We suspect this result is attributable to high levels of trust between economically interdependent states. In this context, states are less resistant to delegating authority and more accepting of institutionalization.

Perhaps surprisingly, the democracy variable is statistically insignificant. This result may reflect two contrary effects. First, democracies may be more accepting of international institutions. Second, they may also be more likely to comply with agreements, so authoritarian leaders may need formal arrangements more than democratic leaders in order to signal credible commitments (Drezner 2003).

The results for the security-related control variables show that all the coefficients are insignificant, with the only potential exception being the foreign policy similarity variable; it teeters on the edge of significance in model 2. These results are consistent with Tir and Ackerman's (2009) findings that military conflict and alliances are unrelated to the formation of river treaties. This may not be that surprising, given the overall consensus that international rivers seem to be a basis for cooperation rather than conflict. Moreover, once established, water cooperation regimes seem to be robust over time, even between states engaged in conflict over other issues (Yoffe and Wolf 1999; Alam 2002; Zawahri 2009a). We also find little evidence that the design of treaties is a function of power, a point of special importance in the debate between neoliberal and neorealist theories. In short, a focus on power distribution offers little insight into the design of river treaties.¹⁵

To better illustrate the relative influence of each variable, Table 3 reports changes in predicted probability. The baseline is the predicted probability of each level of

Table 3. Predicted Probabilities of Institutionalization

Variable	P (0)	P (1)	P (2)	P (3)	P (4)
Model 1					
Baseline	.262	.369	.253	.104	.012
Highly Contentious Issue	-.108	-.020	+.060	+.057	+.011
Upstream/Downstream	+.050	+.008	-.028	-.025	-.005
Econ. Development	+.044	+.007	-.025	-.022	-.004
Trade Interdependence	-.057	-.009	+.032	+.029	+.005
Model 2					
Baseline	.261	.371	.254	.103	.012
Water Quantity Issue	-.133	-.043	+.073	+.084	+.019
Navigation Issue	-.172	-.097	+.083	+.142	+.043
Upstream/Downstream	+.054	+.008	-.030	-.027	-.005
Trade Interdependence	-.058	-.009	+.033	+.029	+.005
Foreign Policy Similarity	-.040	-.006	+.022	+.020	+.004

Note: Column entries report predicted probabilities—calculated using models 1 and 2 in Table 2—of a treaty having 0–4 institutional features.

institutionalization with all the variables held at their mean or modal values. The effect of each dichotomous variable is calculated by changing its value from 0 to 1. For the continuous variables, the effect is calculated for a change in one standard deviation around the mean. Based on the results from model 1, the presence of one of the three highly contentious issues increases the predicted probability of the treaty having three institutional features by about 55 percent, and one of these issues almost doubles the predicted probability of a treaty being fully institutionalized. Conversely, the presence of a highly contentious issue decreases the probability of the treaty not being institutionalized at all by 41 percent. In comparison, the significant control variables exhibit notably less influence.

We also calculate marginal effects for model 2 in order to get a sense of the separate effect of water quantity and navigation. The water quantity issue decreases the probability of the treaty having no institutional features by –51 percent, while it increases the probability of the treaty having three institutional features by about +81 percent and of the treaty being completely institutionalized by about +158 percent. For navigation, the effect is the most substantial, at –66 percent, +137 percent, and +358 percent, respectively. The marginal effects demonstrate additional support for our findings: the substantive effect of each of the issue variables far outweighs the effect of any other variable reported in Table 2. The central issue that states are addressing when they negotiate a river treaty exerts much more influence on the institutional design of the agreement than any of the geographic, economic, or political factors surrounding the negotiations. River use issues, and the multifaceted problems of cooperation that they introduce, are the primary drivers of institutionalization, with navigation being the single most important variable.

Finally, to assess the robustness of our findings, we conducted several follow-up analyses to gauge whether the relationship between highly contentious river issues and treaty design is conditioned by the process that leads states to form treaties in the first place. These analyses use a dyad-year unit of analysis and expand the universe of cases to all contiguous river-sharing dyads, as reported by Toset, Gleditsch, and Hegre (2000). Each of these methods jointly examines separate dependent variables for treaty formation and treaty institutionalization. Specifically, we estimated a two-stage least squares regression, Heckman regressions with both ordinary least squares and ordered probit in the outcome equation, and a bivariate probit with a dichotomous variable measuring whether a treaty was institutionalized or not. The results further increase the confidence in our primary finding. In each analysis, the relationships between issue areas and treaty design reported in model 2 hold even when the process that leads to treaty formation is taken into account. Water quantity and navigation issues significantly increase the level of treaty institutionalization, while the water quality coefficient is insignificant. These results are available from the authors.

Conclusion

Water scarcity due to population growth, development, and global climate change will likely place escalating demands on rivers as a source of fresh water in the coming decades. This trend underscores the importance that international river cooperation will play in the future. International institutions, in particular, will play a critical role in efforts to promote water cooperation and avoid conflict. The literature on river cooperation suggests that the design of water management institutions affects their ability to promote cooperation and resolve conflict (Bernauer 1997; Marty 2001; Giordano, Giordano, and Wolf 2005; Zawahri 2009a).

This study contributes to a better understanding of river cooperation by helping explain the design of river management institutions. It develops and systematically tests an explanation for why some river treaties are highly institutionalized while others contain few, if any, institutional provisions. The primary finding is that treaties that address especially difficult river use issues, specifically water quantity and navigation, are most likely to contain provisions for institutional governance.

These findings complement recent large-N research on international cooperation and conflict over transboundary rivers. Studies by Hensel, Mitchell, and Sowers (2006) and Hensel and Brochmann (2009) conclude that river treaties tend to promote the peaceful management of river conflicts. In addition, Mitchell and Hensel (2007) and Hansen, Mitchell, and Nemeth (2008) find that international institutions tend to promote the effective mediation and settlement of territorial, maritime, and river claims. Taken together, these findings give some reasons for optimism about the prospects for river cooperation and the risk of conflict over water resources. In those situations where sustained cooperation might otherwise be difficult, states are more likely to establish strong international institutions. The empirical findings also demonstrate that issue area is a more important determinant of institutionalization

than geographic, economic, governance, power, and security-related contextual factors. Thus, states will often establish institutions in those situations where other factors might discourage cooperation.

Aside from improving our understanding of the governance of international rivers, this article helps extend institutionalist theory into the increasingly important area of global environmental politics. There is an increasing recognition that institutional design matters for international environmental cooperation (Haas, Keohane, and Levy 1993; Mitchell 1994; Keohane and Levy 1996; Brown Weiss and Jacobson 1998; Young 1999). This literature posits that institutions are a critical component of effective international environmental policy. To date however, there is a relative scarcity of rigorous, large-N empirical research that seeks to account for the origins and design features of international environmental regimes. This study contributes to this literature by providing systematic empirical evidence of the basic, but largely unexamined, assumption that environmental problem structure is a key determinant of institutional design (Bernauer 2002).

Notes

1. Dinar (2006) evaluates the effect of river geography on one particular feature of river treaties, issue linkage, but does not address broader management institutions.
2. <http://www.transboundarywaters.orst.edu/projects/internationalDB.html> (accessed fall 2007).
3. Multiple issue claims are possible between the same riparian disputants in the same year.
4. Flooding is the most frequent source of remaining claims.
5. Admittedly, the views of the ICOW river claims and TFDD river treaty projects on what constitutes navigation issues do not overlap perfectly. Some ICOW navigation claims deal specifically with the issue of the right of passage, which is of only tangential concern to the TFDD project from which we draw our list of treaties (see note 7) and which is focused on navigation concerns as they pertain to the issues of river hydrology, water depth, or water quality. Nevertheless, the ICOW river claims project records all claims related to navigation, even if they do not result from right of passage disagreements; for example, a navigation claim can deal with the failure to dredge a river channel to maintain navigable depth. Even if all the ICOW navigation claims unrelated to the TFDD data were to be taken out, the frequency of residual ICOW river claims is so low (fewer than 2 percent) that it is extremely unlikely that another issue would surpass navigation as more contentious. Finally, the reader is reminded that our use of the ICOW river claims data is limited only to gauging which river issues cause the most controversy; we do not use these data in our actual analyses.
6. Dams constructed exclusively for hydropower will of course not permanently disrupt river flow while in use, but they still give the upstream state the ability to reduce flow to downstream states.
7. The TFDD project records only those navigation treaties that in their text mention river *water* as an issue. Yet, in the context of our project, this restriction is not as severe as it may first appear. The TFDD database includes treaties that address not only the quantity

of water needed for safe navigation or pollution concerns due to excessive river traffic or poor environmental standards of river fleets but also any type of activity that affects river hydrology, such as dredging, channel construction, riverbed widening, straightening of meandering sections, and so on. These issues (especially dredging and prohibition against diverting water in order to maintain navigable depths) are quite common in modern-era navigation treaties, so TFDD's data collection efforts with respect to navigation treaties signed in the time frame under analysis here are much broader than they may first appear. In any case, the following discussion focuses primarily on the navigation–water nexus and less on the issue of the right of free passage, which tends to be the exclusive focus of older navigation treaties and of customary international law dealing with river navigation.

8. Similar incentives to siphon off river water exist due to the overexploitation of ground water sources.
9. The statistics for each institutional provision are based on the sample of river treaties used in our analysis, which is comprised of 315 agreements from the TFDD database formed between 1950 and 2002; see also the research design section below.
10. We exclude a small number of agreements that were signed by colonial powers on behalf of colonies, as well as some agreements signed between Israel and the Palestinian Liberation Organization.
11. Because some treaties address multiple issues, a limitation of this coding scheme is that it does not capture cases in which water quality, water quantity, and navigation are secondary issues. Nevertheless, the primary issue coding provided by this database is meant to capture the most important issue that the signatories are confronting, and thus the issue that is likely to exert the most influence on the design of the agreement.
12. The source does not provide information for noncontiguous states nor for the level of analysis beyond the dyad.
13. Using the mean level of development did not change the substantive results.
14. We tested several other specifications of democracy, including the mean score for the agreement and the difference in scores between the most and least democratic states. None of these alternate specifications changed the results.
15. In our follow-up tests accounting for the process of treaty formation, we, however, find some evidence—albeit inconsistent—that power distribution helps determine whether a treaty is signed in the first place. Thus, realism may be better suited for explaining whether—but not how institutionalized—river treaties are formed.

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