

International River Treaty Effectiveness

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Abstract

While the concept of "water wars" has gained a prominent position in the environmental security literature and in policy debates, the modern world has yet to see any large scale wars over water. Disagreements over water do occur, some of which have led to low-level armed conflict -- but cooperation over rivers has been more frequent. Prior research has identified a number of factors that influence the signing of river treaties, and has found that river treaties have generally helped to prevent the emergence and militarization of disagreements over rivers while increasing water cooperation. This paper integrates these lines of research by simultaneously examining the origins and effectiveness of river treaties covering water quantity, water quality and navigation. We investigate the extent to which the treaties' effectiveness can be explained by the conditions under which they were first signed. After accounting for the processes leading to the emergence of river treaties, the treaties have a separate effect of reducing the likelihood of subsequent disagreements over the river. The observed successes of river treaties therefore cannot be explained simply by them being signed in the most favorable conditions. Importantly, though, this effect appears to be limited to the specific subject of each treaty, rather than being a more general effect whereby any river treaty helps to prevent any subsequent river disagreement.

International River Treaty Effectiveness

Pressure on sources of freshwater – such as transboundary rivers – is expected to increase in coming decades due to factors such as population growth, development, and global climate change. These trends have led some observers to conclude that the world is facing an imminent prospect of water wars and that water will soon replace oil as the main resource countries fight over (e.g. Gleick 1993; Klare 2001). Yet these predictions have not come to fruition thus far, and the primary mechanism through which states have managed water issues has been cooperation -- often in the form of formal river use treaties. More than 3,600 such treaties have been signed since AD 805 (Wolf 1998). Although the proliferation of river treaties may give us reason for optimism, relatively little is known about such treaties' effectiveness in preventing future riparian disputes. This is a critical issue that has to be considered if the world is to keep the projected water conflicts at bay.

Extant research has only recently started to examine the issue of river treaty effectiveness (e.g. Brochmann 2012; Brochmann and Hensel 2009, 2011; Tir and Stinnett 2012). Assessing how effective treaties are, however, is unfortunately not as straightforward as simply comparing whether riparian countries with treaties experience less river-related conflicts than those without. Matters are complicated by the fact that the signing of river treaties itself is a non-random process that emerges from political bargaining and depends on several variables (e.g. Brochmann 2012; Espey and Towfique 2004; Tir and Ackerman 2009). A treaty's effectiveness is therefore likely to be conditioned by the treaty emergence process. Not accounting for this process in the estimation of treaty effectiveness may well lead to biased results and erroneous conclusions. For example, a treaty may appear to be effective at preventing conflict, but the truth may be that the relationship between the riparians has been positive all along. Such a relationship might have led to both the signing of the treaty and the observed good relations after it was signed. In other words, little conflict would be expected in this case with or without the treaty, leading researchers to obtain a false-positive conclusion. Furthermore, to determine if treaties indeed do little to alter state behavior (Downs, Rocke and Barsoom 1996), researchers would need to examine why they are signed in the first place. Conceivably, the circumstances that lead to treaties may differ substantially across cases, and treaties signed under the “right” circumstances could be more effective than those signed under the “wrong” conditions. If the process leading up to the treaty is not accounted for, all treaties are treated the same – leading to insignificant,

false-negative findings. For these and similar reasons, the processes of treaty emergence and conflict-management effectiveness are best examined simultaneously and systemically (Brochmann 2012).

Here, we investigate systematically the extent to which signed river treaties prevent new river disputes from emerging and existing disputes from escalating, *given the processes that have lead to the emergence of the treaty*. We therefore build on existing research by connecting the dynamics that lead to treaty emergence with those that lead to dispute onset and escalation. To accomplish this, we rely on the list of international river treaties provided by the Transboundary Freshwater Dispute Database (TFDD) (Wolf 2008) and a compilation of river-related disputes collected by the Issue Correlates of War (ICOW) project (Hensel 2008); our analyses cover the 1900-2001 period.

The topic of our study is of great importance to the water cooperation literature. Many scholars explicitly state or assume that the signing of a river treaty should reduce conflict and bring about positive relations between the signatory states in the future (e.g. Wolf; Espey and Towfique 2004; Tir and Ackerman 2009). Brochmann (2012) finds that states that have signed river treaties experience more subsequent water cooperation than states that do not have these arrangements. Yet, Zawahri (2008) points out that there are also reasons to doubt that such treaties can help manage riparian conflicts, because signatories may choose not to implement the treaty's provisions (Bernauer, 2002; McCaffrey, 2002) or simply find compliance to be too difficult or costly (Waterbury, 1994, p.44). The treaty may also not introduce much change in the riparian relationship because it does not require a notable – if any – alteration in the signatories' behavior; the treaty hence largely confirms the status quo (Downs, Rocke and Barsoom, 1996). The issue of river treaty effectiveness is therefore not only important but also far from settled.

Research in this area also engages broader theoretical debates surrounding formalized cooperation as a way to manage conflict. For example, the rational design literature (Koremenos 2001) argues that international institutions – including treaties – generally perform their tasks well, because they were designed purposefully and carefully to address specific problems. Yet the international conflict literature has produced a variety of empirical findings about whether treaties are effective instruments for dealing with phenomena such as international wars (Werner 1999), domestic conflict, and territorial disputes (Goertz and Diehl 1992). The circumstances

leading to the treaties may not allow as much of a refined design as thought, may entail too much compromise, may be forced on weaker parties, or may not effectively address incentives to cheat – all of which ultimately may decrease the treaties’ effectiveness in managing future conflicts. Still others argue that agreements fail because, despite good intentions, states often lack the resources and expertise to comply with their obligations (Chayes and Chayes 1993). In short, the present project presents a unique opportunity to engage broader theoretical debates about the utility of formalized international cooperation and does so in the setting of freshwater politics.

In light of these debates, the possibility that the signing of a treaty is not synonymous with successful cooperation between river sharing states has tremendous practical implications. Treaties are not cost-free ventures for their participants. They involve transaction and the so-called sovereignty costs, which entail having to delegate some part of decision-making authority away from the state. Government leaders may thus be reluctant to enter into treaties unless they know that there is a good chance that they will be effective. At the same time, however, policymakers are almost blindly pushing for and committing resources to expand the number of riparian treaties. For instance, the 2006 UN *Human Development Report* – which is largely devoted to water issues – claims that all efforts of cooperation should be supported, including in particular riparian treaties. This call is made without the benefit of knowing whether the agenda is ultimately productive from the conflict management standpoint and resources well spent. Furthermore, some critics take a view that goes beyond simply questioning whether river treaties can deliver on their promise. Zeiton and Mirumachi (2008) argue that an unquestioning push for more river treaties overlooks possible detrimental effects of unfair or asymmetric cooperation, whereby strong states are coercing weak ones into treaties that mostly benefit the strong. Such treaties may in fact lead to *increasing* conflict levels and be worse than no treaty at all. That this concern may not be applicable to only a few outlier treaties is a point a realist would make. Mearsheimer (1994) claims that all international cooperation is essentially a reflection of powerful states’ interests. Any treaty will therefore be biased in favor of the powerful state and leave the weaker state shortchanged and resentful. Formalized cooperation would thus be unable to alter the fundamentally conflictual nature of international politics.

Given the above theoretical and policy concerns, much is at stake in determining whether riparian treaties indeed perform their conflict management functions effectively. This is precisely our aim. In the remainder of this paper, we review the relevant literature, discuss our

theoretical reasoning, develop our research design, and present and discuss our findings. Our results suggest that, in general, signing treaties does not prevent the emergence of later river disagreements between the signatories. In fact, signed treaties seem to increase the risk of new disagreements emerging over the specific issue dealt with by the treaty, at least with respect to treaties over water quantity.

Formalized (River) Cooperation and Conflict Management Effectiveness

Rivers are an essential source of fresh water, which is a vital resource needed for human survival that has no substitutes. Beyond providing water for human consumption, rivers offer the possibility of further benefits ranging from fishing, navigation, irrigation to hydroelectric power generation. Yet, many rivers are shared between two or more countries – making these actors interdependent and requiring at least some level of joint coordination. While disputes do occur among riparians, they also open up political space for cooperation, which in turn commonly becomes codified in the form of international river treaties (Dinar et al., 2007: 141). Although treaties are numerous, few studies have examined whether river treaties actually live up to their expected conflict management potential and prevent later disagreements over the river in question. To shed light on these issues, in this section we turn to the literatures on both general international cooperation via institutions and on formalized river-specific cooperation. The first portion covers the generally positive expectations with regard to institution’s ability to manage conflicts, while the latter part provides a more skeptical view of their conflict management potential.

The Optimistic View

The liberal institutionalist school of thought (e.g. Axelrod, 1984; Keohane and Nye, 1977; Moravcsik, 1997) emphasizes the roles of institutions as forces that not only reduce the chances of armed conflict but also promote interstate cooperation. They provide incentives that increase the parties’ ability to come to a mutually-satisfactory agreement (i.e. increasing the “win-set”) and structure the environment in trust-establishing ways. That is, cooperation between self-interested parties can emerge even under the condition of anarchy, especially when there is an expectation of long-term benefits (Axelrod, 1984). To help facilitate cooperation, states create international institutions – including (river) treaties – that spell out the rewards and obligations of

the signatories, deal with technical details, and perhaps offer dispute-resolving mechanisms. The treaties can consequently change the states' preference toward cooperation by providing predictability, decreasing uncertainty and the costs of cooperation, and increasing the costs of non-cooperation (Moravcsik, 1997). These functions can contribute directly to higher levels of trust and to expanding state preferences to be more inclusive and long-term; this increases the scope of cooperation immensely (Kydd, 2000; Russett & Oneal, 2001).

The rational design literature (Koremenos 2001) argues that international institutions – including treaties – are typically designed purposefully and carefully to address specific problems. As a consequence, institutions are expected to generally perform their tasks well, including being effective conflict management tools. Finally, according to a “managerial” school (Downs et al. 1996: 379), states that engage in formal cooperation such as signing a treaty will intend to comply with the provisions following this treaty (Chayes and Chayes 1993). When they sign a treaty, states establish and adopt a rule system that they tend to honor. According to Chayes and Chayes (1993) this is both the most efficient behaviour and in the states' interests. Reaching a joint decision through negotiation is costly, and can be a time consuming process, and when states invest considerable effort into such negotiations they expect an outcome that is better than the status quo.

In international river basins, treaties are the most common form of formalized cooperation. States may find that their interests in developing the river coincide and acknowledge that cooperation can be efficient, or river treaties can be signed because states try to avoid a future conflict or to end an ongoing conflict. Irrespective of the reason why negotiations to reach treaties are initiated in the first place, however, once the treaty is in place, according to the managerial school, states will tend to comply. They are thus likely to alter their behavior, their relationships, and their expectations of one another over time in accordance with the terms of the treaty, especially if the relationship over the specific issue is long-term.

Much of the above optimism is reflected in the literature on river treaties. The proliferation of river treaties is widely cited in the literature (e.g. Wolf 1998; Tir and Ackerman 2009) and their expected positive effects are taken almost as an article of faith (see Zeiton & Mirumachi's 2008 critique of the 2006 UN *Human Development Report*). Much of the water cooperation literature therefore reflects the view that river treaties create positive-sum situations in which the incentives for further cooperation become palpable (Benvenisti, 1996; Waterbury,

2002) – even in the face of problematic relationships (e.g. the recent Indus River treaty). Yet few studies put the conflict managing potential of river treaties to an actual test.

Some investigations have, however, been undertaken. Based on a review of several disputes between river-sharing states in the Nile, the Euphrates, the Syrdarya, the Ganges, the Danube, the Rhine and the Rio Grande, McCaffrey (2006) argues that the presence of a functional treaty decreases the severity of water disputes, and that political tension is more likely to be present where there is no such agreement. Giordano and Wolf (2003) find that in international basins with high dam densities, relations are significantly more cooperative in basins with established water treaties than in basins without. Brochmann and Hensel (2009) find that although the existence of a treaty does not prevent future water disagreements, states are more likely to enter into negotiations to resolve these disagreements if there is a treaty in place. Treaties do not have a systematic impact on the success or failure of the resulting negotiations, however (Brochmann and Hensel 2011). Examining transborder river pollution, Bernauer and Kuhn (2010) find some evidence that with a river treaty present, European states harm their neighbors less through river pollution than states with no joint treaty. And finally, in a recent study, Brochmann (2012) finds that states tend to cooperate more over their shared rivers in the years following a treaty signing.

The Skeptical View

The optimism expressed above is, however, not shared by all researchers. This is especially the case in the part of the literature that is most relevant to our project: conflict management. Because we focus on the issue of whether river treaties can manage riparian disputes, these views are of particular relevance. International conflict literature has produced several findings that bring into question treaties' ability to successfully manage conflicts. For instance, Werner (1999) finds that war-ending treaties have no appreciable effect on the duration of subsequent peace, that is the chances of war recurrence. Indeed, a long-standing overwhelming victory argument (e.g. Vasquez 1993) maintains that wars ending with overwhelming victories produce a clear victor and so defeat the loser to the point that it is unable to resume fighting. In contrast, negotiated settlements create incentives for the resumption of hostilities. Because there is no clear victor, the relative loser can rationally hope to improve its situation by resuming hostilities. Meanwhile, even the winner may entertain the thought that it could do better than the new status

quo by resuming the fight. These incentives are hardly constrained by the associated treaty (if there is one), implying that it is not the treaty but the war's outcome that makes the difference.

A similar, and quite consistent finding, stems from the civil war literature: peace is more stable and enduring after a war that ends with a decisive victory as opposed to a war that ends in a stalemate or a negotiated agreement (Fortna 2004; Licklider 1995). Analogous observations about factors other than treaties being determinative of whether the fighting resumes can be found in the territorial conflict, international rivalry, and ethnic conflict literatures (e.g., Hensel 1996, 1999; Diehl and Goertz 2000). That is, whether there was a victory, balance of forces, time elapsed since the cessation of hostilities, battle-related fatalities, etc. are often found to be better predictors of post-conflict stability than are conflict-ending treaties. Following these insights, many conflict management or conflict recurrence studies do not even consider treaties to be important enough of a variable to include into analyses, thus implicitly discounting their relevance.

Another well known view in the international relations literature maintains that the *modus operandi* of the international system is for strong states to coerce weak ones into arrangements – including treaties and institutions – that mostly benefit the strong. According to Mearsheimer (1994), all forms of cooperation are thus epiphenomenal to the underlying distribution of power. Treaties would hence have no independent conflict managing effect; they are simply irrelevant. Taking a less coercion-laden view, Downs, Rothe and Barsoom (1996) arrive at a similar conclusion. A treaty may not introduce much change in the interstate relationship because it may not require much if any alteration in the signatories' behavior; such a treaty would largely confirm the status quo. This implies that the signatories' behavior will be unaffected by the treaty.

Dismissing these more negative views about state's motivations, Chayes and Chayes (1993) argue that countries typically enter international agreements with good intentions. Yet, agreements still fail. This happens because states often lack resources and expertise to comply with their obligations. And, conceivably, the "we tried our best" attitude may not be met with all that much understanding on the part of the treaty partners, escalating tensions and seriously undermining the conflict management potential of the treaty.

Some of the above skepticism can increasingly be found in the research on international river treaties. Reflecting some of Mearsheimer's logic, Zeiton & Mirumachi (2008) argue that

river treaties often contain elements of asymmetric cooperation, whereby strong states coerce weak ones into treaties that mostly benefit the strong. Such treaties may in fact lead to increasing conflict levels and be worse than no treaty at all. Another example of skepticism is that the treaty's incentive structure often does not favor future compliance. Any river treaty's success is contingent upon the parties feeling obliged to implement and follow its regulations. Yet, those with the least to gain from the treaty's provisions may feel short-changed and demand to be compensated from parties that are gaining the most. Effectively, the former party retains a semblance of veto power over future cooperation, setting the stage for failed cooperation or perhaps even conflict. A way out of this predicament is not clear. Without the compensation, the party may lack incentives to implement the treaty and there exists no overarching international law with authority to force states to implement signed water treaties (Licklider 1995; Waterbury 1997).

Another source of problems may be found in the treaties themselves. In their systematic review of existing river treaties, Stinnett and Tir (2009) find that relatively few treaties have multi-faceted institutional provisions to deal with problems commonly found within treaties. These problems include vague formulations open to diverging interpretations; critical issues such as water allocations left unsettled (i.e. incomplete contracting); lack of mechanisms for identifying cheating (or non-compliance), addressing it, and punishing perpetrators; lack of procedures for dealing with new issues not covered by the treaty emerging; changing political or hydrological environments; etc. In short, the frequent lack of means to address problems commonly found within riparian relationships does not bode well for the treaties' ability to secure future compliance and act as a successful conflict management tool.

That river treaties may represent a somewhat flawed form of river cooperation may be more obvious to riparian states' governments than to researchers. Although treaties are the most common form of formal riparian cooperation and their number is growing, only a minority of international river basins (117 of 263) is covered by an agreement (Giordano and Wolf, 2003: 168).¹ Waterbury (1997) argues that since most international river basins are not covered by a treaty, this indicates that there are no obvious benefits from reaching these agreements. He points out that the most frequent form of action over international rivers remains unilateralism.

¹ Furthermore, diffusion of agreements to new river basins has been slow, according to Conca et al. (2006: 271). Of the 62 accords they investigated in the period from 1980-2000, roughly three-fourths concern basins with a prior agreement.

In sum, one thus has serious reasons to doubt that river treaties can help achieve desired levels of compliance and act as conflict management tools. Problems arise because signatories may choose not to implement the treaty's provisions (Bernauer, 2002; McCaffrey, 2002), find compliance to be too difficult or costly (Waterbury, 1994; see also Zawahri 2008), enter treaties with good intentions but then find themselves simply unable to satisfy their obligations due to lack of expertise (see Chayes and Chayes 1993), or because the treaties themselves are generally well equipped to deal with problems that commonly arise (see Stinnett and Tir 2009).

Theoretical Framework

As can be seen from the preceding section, there are reasons to believe that a river treaty may be able to manage conflict and prevent emergence of river-related disputes, as well as reasons to believe that a treaty may not be all that effective. In addition, several of the arguments reviewed indicate that the treaty could actually create disputes that would not have occurred otherwise. Determining which of these possibilities is empirically correct is the focal task of the present project. Our primary theoretical innovation consists of the argument maintaining that the emergence of river-related disputes is affected by (1) the presence of a river use treaty, (2) the circumstances under which the treaty was signed, and (3) the general dynamics that lead to the generation of riparian disputes. Parts (2) and (3) capture the broader relationship between the riparians – including economic, political, as well as geographic factors. Accounting for (2) and (3) will help us determine (1), that is whether a treaty can indeed reliably prevent new disagreements over the river from emerging. Prior works have examined portions of this relationship. For example, Tir and Ackerman (2009) examine part (2) while Hensel and Brochmann (2007) and Brochmann and Hensel (2009, 2011) investigate parts (1) and (3) but not part (2).

Admittedly, while none of the three parts by themselves is novel, examining them simultaneously is. Bringing all three parts together is absolutely critical to properly evaluating the conflict-managing effectiveness of river treaties. Treaties emerge as results of interstate bargaining that is highly political and depends on several variables (see Tir and Ackerman 2009). When these dynamics are ignored (e.g. when parts (1) and (3) are investigated in isolation), it may erroneously appear that the treaty is indeed having the desired conflict-managing effect.

Yet, what may really be happening is that the riparians have signed the treaty because of their good relations and the same good relations mean that future river disputes are unlikely. Specifically, some of the treaty-promoting variables, such as democratic governance, history of prior cooperation, or asymmetric power distribution (see Tir and Ackerman 2009), have been found to decrease the incidence of river-related disputes (see Hensel and Brochmann 2007). It is thus possible to conclude that the beneficial variables may prevent disputes whether treaties are in effect or not. This would mean that the treaties would have no independent conflict-managing effect: treaties are merely a function of structural forces that determine both the existence of treaties and generation of disputes. Similarly, the failure to account for the conditions leading up to the treaty negates potential differences that may separate treaties into the more and less effective categories. And ignoring this process basically mixes all the treaties together and may ultimately bias the treaty effect results downward toward insignificance. Whether these suspicions are indeed correct is something that we investigate here.

Accordingly, our theoretical framework is composed of the three key parts named above. Because part (1) is of the greatest concern and speaks most directly to our goal of establishing whether river treaties indeed have the much expected conflict-managing potential, we focus on this part and address it with our main hypothesis. Because parts (2) and (3) are of much lesser theoretical interest to us – though they are crucial from the research design perspective to properly establish the empirical validity of the main hypothesis – we give them comparatively less attention.

River Treaty Effectiveness

Above, we have seen that there are some serious misgivings about whether river treaties can elicit compliance and thus decrease riparian conflicts. In addition to all the shortcomings of the river treaties laid out by past researchers, a possibility exists that both treaties and disputes may be a function of the same structural forces – that is that treaties are simply epiphenomenal to factors driving both outcomes. These important concerns notwithstanding, we still expect that treaties should be able to decrease the likelihood of the emergence of river-related disputes in a systematic fashion.

The reason we expect this is that the act of signing a treaty introduces important new dynamics into the relationship between riparian states. Treaties are generally not the types of

phenomena that states enter into lightly. Negotiating treaties takes effort and resources. Moreover, there are sovereignty costs to treaties, in terms of the signatories having to give up at least some part of their decision-making authority. Treaties are therefore at least somewhat costly signals that the countries are willing to cooperate over their common rivers.

Once this signal has been sent and accepted by the treaty partners, the signatory state's reputation also enters the stage. Reputation is particularly important in a self-help world where no supra-national authority exists to mediate disputes and punish cheaters. If there was a centralized mechanism for punishment, a cheating state could claim that after it has been punished it has fulfilled its "debt to society" and deserves a clean slate. Yet, the lack of such a system may mean that a cheating state has no easy way to undo the damage to its reputation and may have to live with it for a long time. Finding partners to enter into new treaties, alliances, trade deals, etc. should prove difficult and costly as few other states want to risk their resources on a state with a tainted reputation. And just about any state needs these partnerships in order to survive – and, ideally, thrive – in the self-help world. Therefore, a riparian state that has signed a river treaty will have an important incentive to live up to its obligations. Furthermore, encouraging treaty compliance should mean fewer future disputes.

Additionally, prior research on common pool resources suggests that users of such a resource face a constant danger of falling into the tragedy of the commons trap. Unfortunately, there are few ways to avoid this trap other than cooperation with other users. River treaties are probably the most prominent form of cooperation in the river use context and through them the users can specify their obligations and benefits. In contrast, militarized conflict may produce short-term unilateral gains but is not likely to resolve the long-term problem (references). In fact, the use of force will likely damage the possibility for future cooperation and for finding a way out of the trap for all resource users. So, precisely because there are so few ways to deal with the problems associated with the common pool resources, countries and their leaders have an important incentive to abide by the cooperative solutions previously reached and take care not to antagonize their treaty partners. This again should lead to better treaty compliance and a reduction in future disputes.

The above logic does not of course negate that the problems with treaties should not occur; the literature review provides ample evidence to the contrary. Countries may not comply with their river treaty obligations due to remaining incentives to cheat, because of the lack of

resources or expertise, vague language of the treaty, hydrological or other changes in the circumstances, etc. Furthermore, disputes may arise in a bit of a counter-intuitive fashion. Successful treaties may provide grounds for new disagreements to arise, as there may be a smaller threshold to raise new issues if the initiating party feels certain that the disagreement will not escalate to a larger conflict. Nevertheless, while we expect these issues to exist, we do not expect them to be so widespread that conflict-management effects of river treaties are completely negated. We therefore adopt the following general hypothesis.

H1: The signing of a river treaty is followed by a decreased likelihood of a river claim arising between signatory states.

Although we expect signed treaties in general to reduce the risk of new disputes emerging, we expect the pacific effect on the specific issue covered by the treaty to be even stronger. If a specific area is covered by a treaty, the provisions from this treaty should be likely to prevent new disagreements over this specific issue to emerge. We thus expect that -- for example -- states that have a treaty in place that governs water allocation between them should be less likely to experience new disagreements over water quantity.

H2: The signing of a river treaty is followed by a decreased likelihood of a river claim over the specific issue area covered by the treaty.

Research Design

Our empirical analyses investigate the conditions under which states sign river treaties, as well as the conditions under which states become involved in river claims and the extent to which treaties (if they exist) reduce the risk of claims. Because we expect to observe a relationship between states' propensities to sign river treaties and to become involved in river claims, we test our hypotheses using bivariate probit analysis, a technique for use with two equations that are believed to have correlated disturbances (Greene 2000: 849-856). This technique estimates the impact of covariates in each equation as well as testing for correlation between the equations. Specifically, the bivariate probit model's rho parameter measures the correlation between the disturbances (the omitted factors) in each equation after accounting for the influence of the

factors that have been included in the model. Usefully, this technique also allows recursive simultaneous equation models, with the dependent variable of one equation appearing on the right-hand side of the other equation.

In general, the bivariate probit model starts from two probit models with binary dependent variables $y_j, j = 1, 2$ that presumably have correlated error terms:

$$\begin{aligned} y^*_1 &= X\beta_1 + \varepsilon_1 \\ y^*_2 &= X\beta_2 + \varepsilon_2 \end{aligned}$$

y^*_j are latent and related to the binary variables y_j such that y_j takes the value of 1 for all $y^*_j > 0$ and 0 otherwise. The error terms $(\varepsilon_1, \varepsilon_2)$ are assumed to be correlated with correlation ρ . Since the error terms are correlated calculating the two equations simultaneously through a bivariate probit produce more robust results than calculating them separately. According to Greene (2003) the bivariate probit model can be formulated as follows:

$$\text{Prob } [y_1 = 1, y_2 = 1] | X_1, X_2 = \Phi_2(X'_1\beta_1 + \gamma y_2, X'_2\beta_2, \rho)$$

where the probability of observing a given outcome depends on the observations on both y_1 and y_2 and the errors are distributed bivariate normal (Φ_2) and with ρ measuring the disturbance between the two equations. Here, we have a full observability model meaning that we can observe both observations (1 and 0) on y_1 and y_2 .

ICOW River Claims

Our hypothesis will be tested using a data set with one observation for each year that two nation-states share a major international river, with separate observations for each such river that they share; Hensel, Mitchell, and Sowers (2006) and Hensel and Brochmann (2007) offer a more thorough description of the dataset.² Due to data availability, this data set currently only includes rivers in the Americas, Western Europe, and the Middle East, although work is currently underway to expand this to the rest of the world. The list of rivers has been compiled by the Issue Correlates of War (ICOW) project, which defines a major international river as a river of at least

100 miles length that forms or crosses an international border. This information has been collected for the years 1900-2001.

Dependent Variables

Treaty Signing

We identify river treaties using the Transboundary Freshwater Dispute Database (TFDD 2008), which has collected information on hundreds of treaties related to rivers. We are however interested only in those treaties that directly address the three possible types of ICOW river claims (water quantity, water quality or navigation). We thus focus on a subset of TFDD treaties that includes all treaties that focus on any of three topics: treaties addressing the allocation of water quantities between two or more riparian states, treaties with specific water quality provisions, and treaties concerning navigation of international rivers. Treaties with other provisions (e.g. setting the price of hydroelectric power that is produced by a dam on a shared river or agreeing to share technology) are not included.

River Claim Onset

Our main dependent variable is the outbreak of a river claim between two states that share an international river. This variable is taken from the Issue Correlates of War (ICOW) project's data set on river claims, as described by Hensel, Mitchell, and Sowers (2006). Briefly, a river claim involves explicit contention between official government representatives of two or more nation-states regarding the use or abuse of international river waters. For the purposes of our analyses of claim onset, we code a dummy variable that indicates whether or not a new river claim began over a particular river between two riparian states on that river during a particular year of observation.

Independent Variables and Controls

Treaty Signing

The signing of a treaty is also our main independent variable. See description above.

Water Supply

² The data and coding documentation can also be found at www.icow.org

As a measure for water supply we apply basin runoff, which allows us to determine the amount of pressure on fresh water resources in the area. We expect a river that flows through an area where water is scarcer to be considered more important in the sense that we describe in this paper. The Transboundary Freshwater Dispute Database (TFDD) spatial data set at Oregon State University (TFDD 2008) includes two particularly useful basin-level measures of water supply: water discharge (the volume of water that flows through rivers in the basin) and water runoff (the amount of water -- whether from rain, snow melt, or other sources -- that flows over the land surface) in each basin; we apply the latter and it is log-transformed for our analyses.³ It should also be noted that the TFDD data that we employ is only available in snapshot form, with one observation per river basin; there is no time series equivalent that could come close to covering the century-long domain of this study. We thus use this data for the entire time period of the study, arguing that while imperfect, this approach is better than the alternative of excluding water scarcity variables from the analysis entirely.

River length

Our third measure of importance comes from the ICOW project and estimates the length of the river, using the best estimates that can be obtained from a number of major world atlases and geographic reference sources; this variable is also log-transformed.⁴ While the basin-level water scarcity and demands data discussed above describe the general hydrological setting in which a given river flows, there is likely to be substantial variation in the relative importance attributed to individual rivers within this setting. All else being equal, we suggest, a longer river should be considered more valuable than a shorter river.

Cross-border river

To assess the impact of the geographical configuration of a river, we examine whether the river runs across the border from one state in to the other, and thus creates an upstream-downstream

³ Where one or both sides of a given international river are governed as colonies or other dependencies of a foreign power, the water scarcity variables that are used reflect the value for the colony rather than the colonizer, because that is the area affected by the river in question. For example, the water supply and demand figures for France have very little impact on the demand for rivers shared by French Guiana and Brazil, although French Guiana's water supply and water demands likely have a significant impact. All other variables in our analyses (such as democracy and relative capabilities) reflect the colonial ruler, though, as this is the actor that is involved in any conflict or negotiations over the use of the river.

⁴ These rivers have been identified, and their length measured, using a number of sources: the *National Geographic Atlas of the World*, 8th edition; *Times Atlas of the World*, 10th comprehensive edition; *Hammond Concise World Atlas*; Macmillan's *Planet*

relationship. Alternative configurations are “U-shaped” (if the river runs from country A and into B and then back into A) and “border-rivers” (if the river forms the border between the two states) – these are coded as 0. The upstream-downstream relationship is traditionally considered to be the most conflict prone, but also the one that spurs most interaction overall, so we expect to see both more treaties and more conflicts among states in such relationships.

Relative Capabilities

Our analyses control for the relative capabilities of the two states, as measured by the percentage of the total dyadic capabilities held by the downstream state in the dyad. We believe that this is a reasonable way to capture the impact of capabilities on interactions over rivers. The river literature frequently argue that conflicts are more likely where the downstream state is stronger (e.g. Frey and Naff 1985; Homer-Dixon 1999) because a powerful downstream state will be able to put credible force behind a claim towards the upstream state. Brochmann (2012), on the other hand, finds that conflicts among riparians are less likely where the downstream state is power preponderant, but more likely where the upstream state is power preponderant. She argues that in international rivers, traditional power interacts with issue-specific power asymmetries (i.e. river configuration) and reinforces the upstream power advantage where the upstream state is stronger and similarly reduces the asymmetries and hence the conflict risk where the downstream state is stronger. We therefore expect a powerful downstream state to reduce the risk of conflict, but increase the risk of cooperative endeavors, here measured as signing a treaty.

In the dataset, each state's capabilities are measured by the Composite Index of National Capabilities (CINC) score from the Correlates of War (COW) project's National Material Capabilities data set, which ranges from zero to one and indicates the total percentage of the international system's capabilities are held by the state in question during the year of observation (COW 2008).

Joint IGO Memberships

We measure two states' shared memberships in international organizations (IGOs). If two countries have many joint memberships, it is reasonable to assume that they share at least a minimum of common preferences and are more likely to seek to cooperate again. IGOs provide a

forum for information sharing and ease transaction costs of cooperation and we expect spill-over effects to other forms of cooperation. We measure joint memberships in IGOs by summing the number of IGO memberships shared by the two countries in a dyad based on the most updated IGO membership data described in Pevehouse, Nordstrom, and Warnke (2004).⁵ This variable covers a range of organizations from large multilateral bodies like the UN to highly specialized organizations like the Mekong River Commission.

Alliance

The dichotomous alliance variable is coded 1 for dyads where the two countries are members of the same non-aggression pact, entente or defense pact. The data for this variable are from the COW Project.

Joint Democracy

Based on a variety of past research, we expect joint democracy to create an expectation of stability and an atmosphere where agreements are likely to be signed and honored. Joint democracy is measured using the Polity IV data, as a dummy variable indicating whether both riparian states are considered democratic (as measured by a value of seven or greater on the Polity index that subtracts a 10-point index of autocratic characteristics from a 10-point index of institutionalized democracy) (Marshall, Jaggers, and Gurr 2008).

GDP per capita

As a measure for wealth or level of development, we include the GDP per capita in the smallest economy of the two states in the dyad.

Analysis and Discussion

The main interest of this paper is whether or not a signed river treaty will have the desired effect; more specifically, will it reduce the risk of claim onsets in a dyad. Table 1 reports the results from a seemingly unrelated bivariate probit model that investigates what affects the chances of having a treaty present in a dyad, and then in turn what effect such a treaty will have on the risk of later river claims emerging.

⁵ The variable includes 495 different IGOs of all kind with more than 500,000 joint dyadic memberships for the period from 1815 to 2000 (Pevehouse, Nordstrom and Warnke 2004). The original dataset lists is a table of dichotomous variables for IGOs by

[Table 1 about here]

The bottom half of the table examines factors that are associated with the signing of river treaties. Most of the variables in this model have statistically significant effects on treaty signature, and most of these effects are in the expected directions. Treaties are more likely to be signed over rivers that are considered more salient to the riparian states, as indicated by the negative effect of basin runoff (indicating that treaties are less likely in basins that have greater amounts of runoff and thus less concerns about water scarcity).⁶ Treaties are also more likely to be signed over shorter rivers, those that cross borders directly and spend time in each riparian state, and those where the downstream state is weaker than its upstream counterpart. Focusing on the relationship between the riparians, treaties are more likely to be signed between states that share at least one military alliance and between states with lower development levels (as measured by the lower GDP/capita figure in the dyad), although they are less likely to be signed when the riparians share more IGO memberships, and joint democracy does not have a systematic impact.

More interesting for our present purposes, though, is the analysis of river claim onset in the top half of the table. The presence of at least one treaty over the river is associated with a significantly ($p < .001$) higher probability of river claim onset. This is somewhat surprising, as many of the studies discussed earlier suggest that treaties should either promote cooperation (thereby reducing river claims) or have little systematic effect; few scholars have suggested that the presence of treaties should actually increase the likelihood of future disagreements over the use of the rivers in question. It must be remembered, though, that Table 1 aggregates all types of river treaties and all types of river claims into a single analysis; we will also follow up on this by distinguishing between both treaties and claims over water quantity, water quality, and navigation.

Beyond the impact of river treaties, we see from the remainder of this table that river claims are less likely where basin runoff is greater (indicating that water scarcity increases the risk of river claims) and more likely over longer rivers. Claims are also less significantly less

country.

⁶ Water scarcity is a multifaceted concept, so we investigated a number of different ways that the concept can be measured: basin runoff, basin discharge, population density within the basin, the percentage of the basin covered by cropland, and the percentage of the basin covered by irrigated cropland. Unfortunately, these different indicators are too highly correlated to be included in the same statistical model, but they all produced generally similar effects in the analyses that were run.

likely between formal military allies, although joint democracy and the number of shared IGO memberships do not have any systematic impact. Finally, claims are less likely in less developed dyads, based on the lower GDP/capita of the two riparian states.

We now turn to the disaggregated analysis in Table 2, which we expect to provide a more complete understanding of the connection between river treaties and river claims. Separate models are produced for each type of treaty and claim, focusing only on treaties that are directly relevant to the type of claim in question (e.g., using water quantity treaties to study the onset of water quantity claims).

[Table 2 about here]

Beginning with the conditions under which river treaties are most likely to be signed, we see many similarities across the three types of treaties.⁷ For example, all three types are less likely to be signed in water-rich basins with high runoff levels, and more likely to be signed between military allies and between more developed states. There are several instructive differences between the three types, though. Longer rivers are significantly more likely to be covered by water quality treaties, where pollution can have grave consequences for a greater number of water users, although longer rivers are less likely to be covered by water quantity or navigational treaties. Cross-border rivers are significantly more likely to be covered by both water quantity and water quality treaties, because both of these issue areas seem likely to be exacerbated by an upstream-downstream relationship; such rivers are less likely to produce navigational treaties than are rivers that form rather than cross international borders. Finally, joint democracy significantly increases the probability of water quantity treaties while decreasing the other two types, while a greater number of shared IGO memberships increases the probability of water quality treaties while decreasing the other two types; as noted earlier, though, military alliances and higher development levels increase all three.

Turning now to the probability of river claim onset in the top half of this table, we see a very interesting relationship between treaty signature and claim onset. For two of the three types of river issues, water quality and navigation, there is a perfect or near-perfect statistical relationship between the presence of a relevant treaty and the avoidance of river claims. That is,

⁷ The statistical model of navigational river issues encountered difficulties with several of the variables that we sought to include in the model. The model would not converge statistically with all of the variables in the model, so we were forced to remove several variables from the model reported in Table 2. Even after these variables were removed so that the model would converge, STATA would not provide a model Chi-square estimate.

such treaties are so effective at preventing the type of river claim being addressed that the treaty variable could not even be included in the statistical model, which is certainly consistent with our expectation in H2.

For water quantity claims, though, the presence of a treaty over water quantity on the river is associated with a significantly higher risk of claim onset, which accounts for the positive coefficient in Table 1 that was discussed earlier. An important reason for this relationship seems to be that conditions are prone to change over time -- so while the original treaty specified a water allocation that both sides found acceptable at the time, this allocation became less acceptable later. A number of changes seem likely to have produced this effect -- a state that may have accepted a less desirable allocation when it was weaker may feel that it has strengthened to the point where it can demand more water, a state may have developed new industries or sectors that need greater water resources than are allowed under the previous allocation, or the river basin may see long-term decreases in the availability of water due to overuse or short-term decreases due to drought or other climatic variations.

However, although treaties may not be able to prevent new claims from emerging over water allocation issues, previous research have shown that states are more likely to enter into negotiations to resolve these new claims where a treaty is present (Brochmann and Hensel 2011). This is in line with the argument presented earlier that states may in fact be less reluctant to raise new claims where a treaty exists because they have less fear that these new disagreements will escalate.

Beyond the results for the presence of a river treaty, all three types of claims are more likely where water is less plentiful. Claims over water quantity are in addition more likely over long rivers, whereas cross-border rivers are more likely to see claims over navigation. Strong downstream riparians decrease the risk of claims over water quality, something that is consistent with recent results showing that dyads with strong downstream states are the most peaceful (Brochmann 2012). Allied states and democracies have lower risk of claims over water quantity, and two democracies also experience fewer claims over water quality. Finally, GDP per capita decreases the risk of water quantity and navigation claims, but increases the risk of claims over water quality.

Overall, the rho parameters are mostly significant throughout the models, supporting our expectations that that the effects of a signed treaty on subsequent conflict risk are systematically

related to the reasons why a treaty was signed in the first place. (The rho-coefficient is not significant in Model 2III, but it is nevertheless premature to conclude based on that that the two parts of this model are unrelated due to the other mentioned problems with this model.)

To sum up, the presence of a river treaty prevents the emergence of new river disagreements over water quality and navigation. Disagreements over water quantity on the other hand are more likely where there already exists a treaty. We have suggested some explanations for this finding, but further research should investigate this more thoroughly. More research is clearly also needed to investigate further our finding that there are large differences between the different types of river issues. The risk of conflict varies considerably among issue-type. The presence of water scarcity, however, seems to be a strong factor in predicting interaction among riparians. States interact over their shared rivers when access to water is limited. They sign more treaties, but they also have a higher risk of conflict under these circumstances.

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Table 1: Seemingly Unrelated Bivariate Probit Analysis of River Treaties and River Claim Onset (any type of river claim)

<u>Variable</u>	<u>Coefficient (Robust S.E.)</u>
<i>River Claim Onset</i>	
River treaty	1.51 (0.43)***
Log(basin runoff)	- 0.14 (0.02)***
Log(river length)	0.32 (0.06)***
Cross-border river	0.05 (0.13)
Downstream capabilities	- 0.08 (0.13)
Log(shared IGOs)	0.02 (0.03)
COW alliance	- 0.26 (0.09)***
Joint democracy	- 0.22 (0.14)
GDP/capita (lower)	- .000 (.000)*
Constant	- 3.00 (0.29)***
<i>River Treaty</i>	
Log(basin runoff)	- 0.04 (0.01)***
Log(river length)	- 0.33 (0.01)***
Cross-border river	0.24 (0.03)***
Downstream capabilities	- 0.13 (0.03)***
Log(shared IGOs)	- 0.02 (0.01)***
COW alliance	0.10 (0.03)***
Joint democracy	- 0.03 (0.03)
GDP/capita (lower)	.000 (.000)***
Constant	1.00 (0.08)***
Rho (S.E.):	- 0.60 (0.17)***
X ² :	2714.34 (17 df, p<.001)
N:	16,879

* p < .10, ** p < .05, *** p < .01 (robust standard errors in parentheses).

Table 2: Seemingly Unrelated Bivariate Probit Analysis of River Treaties and River Claim Onset (split by type of river claim)

	Model I: Water Quantity	Model II: Water Quality	Model III: Navigation
Variable	Coefficient	Coefficient	Coefficient
<i>River Claim Onset</i>			
Relevant river treaty	2.35 (0.34)***	[Perfect]	[Near-perfect]
Log(basin runoff)	- 0.17 (0.02)***	- 0.11 (0.05)**	- 0.05 (0.02)**
Log(river length)	0.41 (0.06)***	0.07 (0.10)	N/A
Cross-border river	- 0.13 (0.12)	0.46 (0.40)	3.83 (0.12)***
Downstream capabilities	- 0.16 (0.13)	- 0.76 (0.38)**	0.12 (0.33)
Log(shared IGOs)	0.03 (0.03)	0.03 (0.06)	- 0.03 (0.05)
COW alliance	- 0.37 (0.09)***	0.18 (0.18)	0.10 (0.21)
Joint democracy	- 0.22 (0.13)*	- 1.02 (0.33)***	0.09 (0.25)
GDP/capita (lower)	- .000 (.000)**	.000 (.000)***	- .000 (.000)**
Constant	- 3.20 (0.30)***	- 2.93 (0.60)***	- 6.19 (0.32)
<i>Relevant River Treaty</i>			
Log(basin runoff)	- 0.02 (0.01)***	- 0.20 (0.01)***	- 0.10 (0.01)***
Log(river length)	- 0.33 (0.01)***	0.07 (0.03)**	- 0.17 (0.02)***
Cross-border river	0.33 (0.03)***	0.10 (0.05)**	- 0.03 (0.01)***
Downstream capabilities	0.04 (0.03)	- 0.83 (0.08)***	N/A
Log(shared IGOs)	- 0.03 (0.01)***	0.05 (0.02)**	- 0.03 (0.01)***
COW alliance	0.08 (0.03)***	0.16 (0.06)***	0.34 (0.03)***
Joint democracy	0.27 (0.03)***	- 0.28 (0.09)***	- 0.52 (0.04)***
GDP/capita (lower)	.000 (.000)***	.000 (.000)***	.000 (.000)***
Constant	0.57 (0.09)***	- 1.21 (0.17)***	0.30 (0.11)***
Rho (S.E.):	- 0.80 (0.09)***	- 0.99 (0.09)***	0.11 (0.18)
X ² :	2833.48 (17 df)***	2315.97 (16 df)***	N/A
N:	16,879	16,879	16,879

* p < .10, ** p < .05, *** p < .01 (robust standard errors in parentheses).