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Climate Change and Water Variability

Do Water Treaties Contribute to River Basin Resilience?

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Abstract

Climate-driven water variability is a natural phenomenon observed across river basins, but predicted to increase due to climate change. Environmental change of this kind may aggravate political tensions, especially in regions that are not equipped with an appropriate institutional apparatus. This paper argues that attempts to assess the ability of states to deal with variability in the future rests with considering how river basins with agreements have fared in the past. The paper investigates whether basins governed by treaties witness less tension (and by extension more cooperation) over shared water in comparison with those basins not governed by treaties, using the 1948–2008 country dyads event data from the Basins at Risk project. The results provide evidence to suggest that the presence of a treaty promotes cooperation. Furthermore, the number of agreements between riparian countries has a significant positive effect on cooperation, which is robust across different specifications controlling for a broad set of climatic, geographic, political, and economic variables.

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Climate Change and Water Variability: Do Water Treaties Contribute to River Basin Resilience?

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Introduction

Climatic conditions have a direct impact on the hydrology of river basins. Climatic change will most likely affect the variability of river flows and have a variety of additional impacts on the hydrologic cycle (Jury and Vaux 2005; Miller and Yates 2006). The change in flow variability will affect populations that will be less able to rely on current water availability and supply trends (Milly et al. 2008). Changes will not be uniform and each region will experience either increases or decreases in river discharge compared with present observations (Palmer et al. 2008).

Hydrologic variability creates a significant challenge especially for countries sharing international river basins. Unanticipated high or low flow events may lead to flooding, severe drought, destruction of infrastructure and human lives, and water resource disputes. Some observers have stressed that, be it in the form of heightened political tensions or more extreme violent exchanges, climate change and the projected increase in water variability may further complicate existing shared water management strategies and may have significant economic, social, environmental, and political consequences (Adger et al., 2005; Walker et al., 2006).

Given the links between climate change, water variability, and inter-state tensions, the role of institutions in assuaging potential conflicts between states seems paramount (Salehyan, 2008: 317). In the realm of international water, treaties often constitute the main governing apparatus and a major means to foster cooperation (Brochmann, 2012). Guided by the extant literature that focuses on international water treaties, this study explores whether the presence of a treaty (or treaties), in fact, makes a difference and promotes increased cooperation. Below we provide some theoretical justification as to the importance of treaties. Next, we present our variables and hypotheses in the data description section. Then, we present the analysis and results and finally, we conclude with policy recommendations.

How Important Are Treaties? A Literature Review

Scholars have long touted the importance of treaties in promoting cooperation and preventing or assuaging disputes among countries (Mitchell 2006). Although signing a treaty does not guarantee a future of stable cooperation (Downs et al., 1996), it nevertheless provides states with a structured means to organize their affairs and manage disputes in an attempt to avoid conflict (Weiss and Jacobson, 1998). According to Chayes and Chayes (1993), treaties alter states' behavior, their

respective relationships, and their expectations of one another, creating a framework for extended interaction. According to Barrett, treaties help states coordinate their actions, especially when unilateralism fails to sustain a mutually satisfying outcome and to prevent free-riding (Barrett 2003, xiii). To do this, treaties must be self-enforcing by being individually rational as well as collectively rational. According to Barrrett, these two types of rationality imply that no party to the treaty can gain by withdrawing and that no party can gain by failing to comply given the treaty's design (Barrett 2003, xiii). To be self-enforcing, treaties must also be fair and perceived by the parties as being legitimate (Barrett 2003, xiv).

Specific to water, evidence suggests that the likelihood of political tensions is related to the interaction between rates of change (physical or institutional) within a basin, and the absence of institutions (such as treaties) to absorb that change (Wolf, Stahl, and Macomber, 2003; Stahl, 2005). Consequently, regions and basins that are not governed by treaties or water-related institutions and facing increased future variability may be more vulnerable to tensions and conflict. Treaties that govern river basins, therefore, constitute an important means for managing transboundary water resources thereby assuaging the escalation of disputes. According to McCaffrey (2003: 157), "treaties stabilize [the relations of states sharing a river] giving them a level of certainty and predictability that is often not present otherwise." In turn, water agreements promote wider cooperation and enhance basin security more generally by altering state behavior, their relationships and expectations of one another in accordance with the terms of the treaty (Conca and Dabelko, 2002; Dinar 2011; Intelligence Community Assessment, 2012; Brochmann 2012).

Empirical studies have largely confirmed such arguments pertaining to treaties and cooperation. Brochmann and Hensel (2007; 2009), for example, find that while the existence of river treaties does not necessarily prevent disagreements (operationalized as conflicting country claims) between states over their shared water resources, the presence of at least one treaty over the specific subject of the claim reduces the likelihood that the claim becomes militarized. In addition, the treaty provides an important starting point that greatly increases the likelihood of negotiations over such claims.[2] Empirical studies provide support that treaties likewise have a

[2] Despite the success of treaties in providing a starting point for negotiations over a conflicting claim, Brochmann and Hensel (2012) find that the presence of a treaty does not necessarily guarantee successful negotiations over the claim and a subsequent end to the claim.

positive impact on promoting longer-term cooperation. Examining post-treaty cooperation in the form of cooperative water events, Brochmann (2012) finds that there is an increased probability that treaty signatories experience more cooperative water events compared to non-signatories. This is most salient during the immediate years following the signing of the treaty.

Additional research examined the impact of treaty design, rather than just the mere presence of a treaty. De Stefano et al. (2012), for example, map institutional resilience to water variability in transboundary basins and combine that information with both historic and projected water variability. In addition to mapping whether the basin is governed by a treaty, the authors consider whether any of the treaties codify mechanisms including water allocation, water variability management, conflict resolution, and a joint commission. Another study (Tir and Stinnett 2012) considers whether treaties with such institutional mechanisms as monitoring, conflict resolution, enforcement, and joint commission help assuage conflict. Using military conflict between states as their dependent variable, the authors find that conflict is increasingly mitigated the larger the number of the above-mentioned mechanisms codified in the treaty. Dinar et al. (2015) find similar results pertaining to these four institutional mechanisms. In addition, Dinar et al. (2015) examine the water allocation mechanisms codified in the agreement and find that water allocation mechanisms that engender both flexibility and specificity (directness) bode better for the treaty's effectiveness in the long term. Mitchell and Zawahri (2015) consider information and data exchange, and find that along with an enforcement mechanism, treaties with these two provisions are most effective for preventing militarization of contentious river claims and increase the chances that negotiations over river claims successfully resolve the issues at stake.

Despite the role of water agreements in assuaging conflict (Brochmann and Hensel, 2009; Brochmann, 2012), some scholars have suggested that the mere presence of an international water treaty does not provide any guarantee that it will ultimately contribute towards sustained cooperation (Dombrowsky, 2007). On the one hand, this may imply that a type of hydro-hegemonic relationship is unfolding – whereby the treaty is only institutionalizing the innate power relations in the basin and any "cooperative" behavior being observed is really the efforts of the basin hegemon to impose a particular regime (Zeitoun and Warner 2006). On the other hand, this may suggest that treaties are mere "paper tigers." In other words, although the purpose of signing a treaty is to prevent free-riding, cheating may still occur since cooperation depends on both the

intentions of the states involved and their capacity to carry out treaty provisions, which may be lacking (Brochmann 2012).

Inspired by the works of Brochmann (2012) and De Stefano et al. (2012), we set out to empirically examine whether basins governed by treaties exhibit resilience, in the form of cooperation as opposed to conflict, in comparison to basins (or basins at one point in time) not governed by treaties under conditions of water variability. We make a number of contributions to the existing literature. In contrast to De Stefano et al.'s (2012) study, we subject a number of variables to a large-n empirical investigation, examining the relationship among the presence, and number, of treaties and water variability as well as level of conflict and cooperation among riparians. In comparison to Brochmann's (2012) study, which uses the same dependent variable, we not only consider a longer time period (1948-1999 versus 1948-2008), but we likewise examine whether water variability impacts basin resilience given the existence (or absence) of a treaty and number of treaties.[3] In the data section below, we describe our dependent and independent variables as well as our controls. Along with the description, we provide hypotheses regarding the expected impact of each variable.

Data

Treaties

Resilience and hydropolitical stability are evidenced when riparians evince more cooperative behavior relative to conflictive behavior, which can be achieved when a basin is governed by a water treaty (Wolf, 2007; Brochmann, 2012). In order to examine whether river basins governed by treaties exhibit resilience in the context of water variability, we coded all country dyads and identified whether that dyad is governed by a treaty. For country dyads with a treaty, we pay close attention to when the first treaty was negotiated. The time-period after the first treaty is signed is

[3] Due to the most recent update of the TFDD treaty database (Giordano et al. 2014) and of the water event data set (De Stefano et al. 2010), this paper included 220 treaties and 755 water events more than the one by Brochmann (2012).

considered the post-treaty period. Since country dyads may sign more than one treaty, we also recorded the number of treaties signed until 2008 (end year of our study) or any other appropriate end year (e.g. if the country ceases to exist at a certain year prior to 2008). While it may be true that one successful agreement may preclude the negotiation of additional agreements, we contend that increased variability across time may require additional agreements between the protagonists to solve lingering environmental change. On a whole, we expect those country dyads governed by more treaties to exhibit additional resilience. Treaty data are retrieved from the Transboundary Freshwater Dispute Database (TFDD) international treaty database. In terms of variables, we used a dummy variable indicating the presence or absence of a treaty between dyad partners (***Treaty***), as well as a continuous variable indicating the number of treaties (***Number of Treaties***) signed between them.

Basin Events of Conflict and Cooperation

To identify whether a river basin governed by a treaty tends to be more resilient to the impacts of water variability, we utilize a combined measure of conflict and cooperation. We use this proxy because river riparians most often exhibit both types of relations throughout time (Zeitoun and Mirumachi, 2008).[4]

We develop our combined conflict-cooperation indicator based on the water events data stored in the International Water Events Database at Oregon State University (OSU), created under the framework of the Basins at Risk project (BAR) and covering the period 1948-2008 (Yoffe et al., 2003; De Stefano et al., 2010).[5] Each event includes a brief summary and source of information coded by date, country pair (dyad), basin, and issue area. Each event is also coded according to

[4] Such a measure provides a comprehensive assessment of hydropolitical relations in the basin which could potentially be inaccurate if one only considered conflictive or cooperative behavior alone. For the sake of completeness, however, we also ran separate regressions using only cooperative events and only conflictive events. Results from these regressions were not qualitatively different from those obtained using the combination of both types of events.

[5] Other databases utilized in large-n studies pertaining to conflict and cooperation over water include the Correlates of War (used by Tir and Stinnett, 2012) and Issues Correlates of War (used by Brochmann and Hensel, 2009). Despite their merits, the Correlates of War database pertains to all forms of militarized conflicts (so the reason for the conflict may not necessarily be water related) and the Issues Correlates of War only pertains to conflicting claims (contentious events) and research is still underway to collect claims data for basins/countries in Asia, Africa, and parts of Europe.

the type of event (conflictive or cooperative) and its intensity using the BAR scale, which ranges from –7, the most conflictive (war), through 0 (neutral events), and up to +7, the most cooperative (voluntary merging of countries).

To extract the events examined in this study, we categorized the events data as they relate to country-basin dyads with no treaties and those country-basin dyads with treaties. For those country-basin dyads with treaties, we also categorized the events data paying close attention to the period before and after a treaty governed the basin in order to compare the two time-periods. The data processing produced a database listing the number and intensity (BAR values) of all the events relevant to each country-basin dyad. This is in line with previous studies using BAR events data (e.g. Yoffe and Larson, 2001; Brochmann, 2012).). There were no examples of extreme scores (-7 or 7). As one of the primary goals of this study was to investigate the impact of treaties, in cases with a BAR score of positive 6 (the signing of a treaty), we subtracted one observation from the total number so as not to attribute the signing of the treaty as an outcome of the treaty. The distribution of events is shown in Figure A1 in the Appendix. In conducting our regression analysis, we used (***AvgBAR***) as a dependent variable, which was the mean of the anti-logged values of conflictive and cooperative relations between the countries. Anti-logs were used instead of actual BAR scores in order to amplify the increasing differences in scale for more extreme events, as is common in previous work using BAR values (e.g., Yoffe et al., 2003).

Water Variability

While water variability is an inherent characteristic across river basins, climate change is predicted to intensify such variability. All else being equal, higher water variability has been shown to lead to political tensions between states sharing river basins (Yoffe et al., 2004; Stahl, 2005).[6] Results presented in Wolf, Stahl and Macomber (2003: 1), for example, demonstrate that "extreme events of conflict were more frequent in marginal climates with highly variable hydrologic conditions, while the riparians of rivers with less extreme natural conditions have been more moderate in their conflict/cooperation relationship."

[6] According to the National Intelligence Assessment (2008) "climate change could threaten domestic stability in some states, potentially contributing to intra- or, less likely, inter-state conflict, particularly over access to increasingly scarce water resources.

For the most part, empirical studies investigating international conflict and cooperation over water have utilized static measures of water availability, which often proxy for scarcity. Interestingly, the work by Brochmann (2012), which focuses on the impact of treaties on basin cooperation, does not include any variables proxying for water scarcity or variability. Given that this study focuses on whether basin country dyads governed by treaties evince more cooperation than those basin country dyads that are not governed by treaties, specifically under conditions of variability, we use the coefficient of variation (CoV) for precipitation to measure climate-driven water variability in each basin dyad. Precipitation data from the Climate Research Unit Time-Series (TS) Version 3.23 (Harris et al. 2014)[7] are the input values for the precipitation CoV. The CoV is calculated to measure inter-annual precipitation over all monthly observations for the relevant time-period (1901-2008).[8] Our rationale for calculating the CoV as a long-term measure is based on our empirical assumption that water variability is embedded in the basin's history and that it is long-term water variability that affects conflict and cooperation over time in a given basin. Our CoV measure likewise follows precedent set by previous studies (Dinar et al., 2010; Dinar et al., 2011; De Stefano et al., 2012).

The literature touting a relationship between climate change and conflict would suggest that high water variability is not conducive for cooperation. However, some research has found that water scarcity can facilitate treaty formation (Tir and Ackermann, 2009). In fact, some studies have identified a more nuanced relationship between water scarcity (and variability) and treaty formation, whereby formal cooperation is enhanced only up to a certain level of scarcity (and variability), after which formal cooperation is negatively affected as scarcity and variability continue to increase (Dinar, 2009; Dinar et al., 2010; Dinar et al., 2011). In light of the findings in the extant literature, our model tests for both linear and nonlinear effects (***Precipitation CV and Precipitation CV Squared***) between variability and cooperative/conflictive behavior.

[7] Accessed Version TS3.23 on 9 February 2016.

[8] Using run-off data provides another way to measure variability but run-off data is not consistently available on a yearly basis like the precipitation data, which is also available across a much longer time frame. See World Bank Water and Climate Change Project (World Bank, 2009) and CLIRUN-II (Strzepek et al., in preparation).

Geography

The physical attributes of shared rivers have long been recognized as important to understanding conflict and cooperation over transboundary water (e.g. Le Marquand, 1977; Toset et al., 2000). In particular, empirical studies considering the river basin as the unit of analysis find that the greater the significance of the particular basin to the respective countries the higher the cooperation evinced. In addition, the more control a country has over a given river basin the less cooperation (or more conflict) is evinced because that country perceives more benefits from unilateral action (Espey and Towfique, 2004; see also Gleditsch et al., 2006).

Following Espey and Towfique (2004), we derive two sets of geographic measures. The first set proxies for the level of control a given country (within the dyad) has over the basin as well as the level of control the entire country dyad has over the basin. The second set proxies for the importance of the basin to a given country (within the dyad) as well as the importance of the basin to the entire country dyad. The measure for control is estimated by calculating the percentage of the total river basin within the boundaries of each country, while the proxy for importance is derived from the size of the river basin within the country, expressed as a percentage of the total area of the country. Two numbers are then obtained for that dyad in order to gauge asymmetry and country-wide nuances: a ratio derived value and a sum-derived value (***Basin Control Sum; Basin Control Ratio; Basin Importance Sum; Basin Importance Ratio***). The variables are calculated from data in OSU's International River Basin Register. The geography variables are time invariant since physical attributes of a basin, generally, do not change drastically over time. We are able to account for the changes that took place during the collapse of the Soviet Union as well as other major geopolitical changes using the International River Basin Register.

Governance and Democracy

Based on the Democratic Peace Theory, scholars have claimed that political regime type should also matter for explaining conflict and cooperation over the environment. Neumayer (2002a), for example, finds that democracies tend to exhibit higher environmental commitment. Gleditsch (1998) suggests that democratic countries sharing a river should be more peaceful in their hydropolitical relations in comparison to non-democratic countries. Brochmann and Hensel (2009), who consider conflictual river claims and their subsequent settlement, find that river claims are less likely to

begin, and more likely to experience peaceful settlement attempts if claims do begin, between two democracies as opposed to dyads with less democratic forms of government. Tir and Ackerman (2009) make a similar conjecture and find that dyads with joint democracies are more likely to negotiate water treaties.

Despite this democratic peace rationale, which suggests that democratic countries are better stewards of the environment and will be more likely to cooperate with other democracies, the literature has also found insignificant and even negative and significant results (Brochmann 2012).

We test the democracy argument and calculate a combined democracy score for the relevant period of each dyad (***Democracy***) based on the Polity IV database (Marshall, Gurr, and Jaggers, 2013), which ranges from -10 for institutionalized autocracies to 10 for institutionalized democracies. The data for the democracy variable are derived for the 1945-2008 period.

Overall Relations: Alliances

Overall political relations between countries should also affect their hydropolitical relations (Yoffe, Wolf, and Giordano, 2003: 1117; Brochmann and Hensel, 2009: 415). We use measures of a history of alliances to proxy for overall relations between states sharing a river basin.

Following Tir and Ackermann (2009), we expect states with common security interests to form military alliances, which afford them the opportunity to enhance security, stability and order. In turn, these shared interests can lead to an increase in mutual trust and result in the attainment of additional objectives in other realms (e.g. environmental) (Keohane 1984). We therefore hypothesize that countries with an overall robust history of alliances will be more likely to experience cooperative events and less likely to experience conflict. The intensity of these events should also be affected. To measure the existence and robustness of alliances, we use the Correlates of War (COW) data set (Militarized Interstate Disputes, v3.1). We include a dummy variable (***Alliance***) depicting whether an alliance exists between the riparians over the respective period of the dyad. The data for the alliance variable are derived for the 1945-2008 period.

Power and Wealth

The literature provides a variety of views relating to the role of power in international hydropolitics. Some authors have claimed that an asymmetric inter-riparian power relationship impedes international cooperation over shared rivers (Hijri and Gray, 1998; Just and Netanyahu, 1998). Others (particularly those echoing neorealist assumptions) have argued that hegemony, or

power asymmetry facilitates cooperation especially when the stronger party is downstream and initiates and imposes a cooperative regime (Lowi 1993). Empirical studies have likewise found evidence for the links between power asymmetry, cooperation, and reduced conflict (Toset et al., 2000; Song and Whittington, 2004; Tir and Ackerman, 2009).[9]

Authors associated with the neo-liberal institutionalist school of international relations have seconded the importance of hegemony for explaining international cooperation, but have argued that such asymmetry is not a necessary prerequisite for cooperation (Keohane, 1982; Keohane, 1984; Young, 1989: 353; Barrett, 2003). This argument has also been confirmed in some empirical works on international water treaty formation and negotiation onset, suggesting that even countries of equal power cooperate (Espey and Towfique, 2004; Brochmann and Hensel, 2009; Dinar et al., 2011).

Further challenging neorealist claims, examples may be cited to demonstrate that even the hegemonic downstream riparian acts in a rather benign nature whereby cooperation is not coerced or enforced, but rather it is encouraged and sustained (e.g. India-Bhutan hydropolitical relations). Cases where the upstream state is also the hegemon and cooperates willingly with an otherwise weaker downstream state can likewise be found in the literature (e.g. 1973 Colorado River Agreement between the United States and Mexico). As Linerooth writes in the context of pollution control, "the more developed upper riparian nations may wish to create 'good will' with their neighbors by contributing more to pollution control while [themselves] benefiting less" (1990; see also Shmueli, 1999). Finally, and based on this latter argument regarding power asymmetry, studies have claimed that cooperation in the environmental realm may be better encouraged and sustained using incentives rather than coercion (Young, 1994; Barkin and Shambaugh, 1999).

Given the varied expectations and empirical results regarding power and conflict and cooperation over water, we examine both power asymmetry and asymmetry in wealth (and the wealthier state's proclivity to create goodwill through incentives). To reflect power and welfare asymmetry, we use annual country-level real GDP and per capita GDP data from Gleditsch (2004). Average values of these two variables were calculated for each of the dyad countries for the relevant time period. Ratios of these average values were then calculated for each dyad, with the

[9] It is important to note that these results and arguments could also be supporting the 'hydro-hegemony' school of thought, which argues that the most powerful state in the basin is able to determine the outcome of basin interactions, including cooperation, assuming the most powerful state will benefit from such a policy (Zeitoun and Warner, 2006)

larger value country serving as the numerator and the lesser value the denominator, such that larger values always indicate greater asymmetry. The ratio of total GDP (***GDP Ratio***) is a measure of overall power asymmetry, or economic power, while the ratio of the per capita GDP (***GDP per Capita Ratio***) is a measure of wealth asymmetry, or welfare power.[10]

Methods

In this analysis, we examine the link between treaties and cooperation under water variability. The unit of observation was a river-basin dyad during a particular time period. For dyads with no treaty, that period was the whole 1948-2008 time span, unless the country was created after 1948. In that case, the period of observation was from the date of creation until 2008 or the year that country ceased to exist, if that happened before 2008. For dyads with at least one treaty, we distinguished between the period prior to the signature of the first treaty and the period after it. We estimate the following regressions:

$$\boldsymbol{AvgBAR = \beta_0 + \beta_1 Treaty + \beta_2 CoV + \beta_3 CoV^2 + \beta_4 X + \epsilon} \quad (1)$$

$$\boldsymbol{AvgBAR = \beta_0 + \beta_1 TreatyNumber + \beta_2 CoV + \beta_3 CoV^2 + \beta_4 X + \epsilon} \quad (2)$$

where *AvgBAR* is the mean of the anti-logs of BAR events, *Treaty* is a binary (0/1) dummy representing the absence or presence of a treaty, *TreatyNumber* is the number of treaties that have been signed by that particular dyad for the given basin (not including the initial treaty signing, as mentioned above), *CoV* and CoV^2 are the coefficient of variation for precipitation in the basin in linear and quadratic form and *X* is a vector of control variables.

Our main variable of interest is the level of cooperation measured as the average of the anti-logs of BAR events. For pre-treaty observations the BAR values were only for that period. For basins with no treaty and with a treaty, the entire time period was used.

Analysis and Results

Descriptive statistics suggest that the vast majority of dyads examined (nearly 80%) had no events, either cooperative or conflictive included in the BAR database (Table I). They therefore, played no role in further analysis of levels of cooperation. That is, the analysis included only those dyads

[10] In some cases, GDP data were unavailable prior to 1950. In such cases, the ratio for 1950 was used.

for which there were event data. The mean BAR score for dyads without treaties and those with treaties was similar, with a slightly higher value for those with treaties. Nearly 56% of all observations had alliances, while over 68% of those with treaties had some sort of military alliance (*Alliance*). The mean democracy score (*Democracy*) for observations with treaties was nearly triple the score for observations without treaties. There is almost no difference in the coefficient of variation of precipitation between observations with and without treaties.

Table I – Summary Statistics

	All Observations	Observations With Treaties	Observations Without Treaties
Observations	1599	426	1173
Observations with events	320	168	152
Mean BAR value for dyads with events	1.664	1.643	1.686
Average number of treaties per dyad	0.802	3.004	0
Observations with alliances	881	283	598
Mean democracy score	0.549	1.446	0.224
Coefficient of variation of precipitation	0.1406	0.1408	0.1399

Table II presents the results with the ***Treaty dummy*** variable and Table III those results with the ***Number of Treaties*** variable. We present four models for each specification according to Equations 1 and 2: Geographic Controls (Columns 1 and 5), Political Controls (Columns 2 and 6), Political and Geographic Controls and no CoV (Columns 3 and 7), and Full model (Columns 4 and 8). In both cases, the regressions are presented in stepwise form beginning with a reduced form model and extending to a full form model including all independent variables.

The mere existence of a treaty seems to have a positive impact on cooperation in two of the four model specifications (Table II). The results for the number of treaties and their impact on cooperation are more robust than the results for the mere presence of treaties, showing a significant positive correlation across all model specifications (Table III). These two findings seem consistent with the findings of Brochmann and Hensel (2007; 2009; 2012). The authors find that while the existence of a river treaty does not necessarily prevent disagreements (operationalized as conflicting country claims) between states over their shared water resources, the presence of at least one treaty over the specific subject of the claim provides an important starting point that greatly increases the likelihood of negotiations over such claims. In other words, the existence of at least one treaty seems to provide the context for continued negotiations, which could take the form of additional treaties. Those subsequent treaties signed in a given basin may, in turn, suggest two possible trends. First, earlier treaties require updating to meet changing needs over time. Second, those subsequent treaties are often more specific in their application in comparison to the original treaty, which tends to be general in scope, and may have a more positive impact on cooperation (Dinar 2008).

Table II – Estimates of the impact of treaty dummy on cooperation

	(1)	(2)	(3)	(4)
Treaty dummy	4.953 (3.302)	6.502* (3.508)	5.794* (3.380)	5.199 (3.321)
CoV	538.802*** (171.631)	558.177*** (168.783)		568.414*** (170.548)
$(CoV)^2$	-1299.975*** (465.388)	-1388.05*** (471.344)		1397.947*** (454.859)
Ratio Basin (control)	-0.202 (0.163)		-0.123 (0.172)	-0.161 (0.175)
Sum Basin (control)	0.036 (0.051)		0.067 (0.051)	0.023 (0.053)
Ratio Basin (importance)	-0.004 (0.003)		-0.004 (0.003)	-0.006* (0.003)
Sum Basin (importance)	-1.932 (6.460)		-1.925 (7.133)	-0.0291 (7.468)
Alliance		-1.178 (3.341)	-2.325 (3.824)	-0.708 (3.776)
Democracy		-1.321*** (0.362)	-1.336*** (0.380)	-1.338*** (0.365)
GDP Ratio		-0.014** (0.006)	-0.021*** (0.007)	-0.013** (0.006)
GDP Cap Ratio		-0.541 (0.803)	-0.465 (0.797)	-0.350 (0.759)
Constant	-30.672*** (14.564)	-30.214** (13.659)	16.892*** (4.410)	-30.928** (15.089)
Observations	320	314	314	314
R-squared	0.069	0.110	0.0680	0.1189

Notes: Robust standard errors are in parenthesis, where *** is significance at the 1% level, ** significance at the 5% level, and * significance at the 10% level.

Table III – Estimates of the number of treaties on cooperation

	(5)	(6)	(7)	(8)
Number of Treaties	2.222* (1.149)	2.218** (1.109)	2.154* (1.136)	2.172** (1.103)
CoV	542.363*** (169.271)	561.749*** (165.968)		570.475*** (165.747)
$(CoV)^2$	-1282.696*** (452.247)	-1385.939*** (460.032)		-1384.804*** (435.890)
Ratio Basin (control)	-0.271 (0.197)		-0.187 (0.192)	-0.227 (0.201)
Sum Basin (control)	0.023 (0.050)		0.0679 (0.051)	0.021 (0.053)
Ratio Basin (importance)	-0.004 (0.003)		-0.004 (0.003)	-0.005* (0.003)
Sum Basin (importance)	-1.862 (6.246)		-2.344 (6.753)	-0.650 (7.077)
Alliance		-2.433 (3.126)	-3.560 (3.557)	-2.203 (3.436)
Democracy		-1.321*** (0.356)	-1.333*** (0.374)	-1.334*** (0.358)
GDP ratio		-0.014** (0.006)	-0.020*** (0 .007)	-0.012** (0.006)
GDP cap ratio		-0.177 (0.749)	-0.090 (0.767)	-0.043 (0.724)
Constant	-32.023** (14.640)	-31.434** (13.789)	16.330*** (4.572)	-32.016** (14.941)
Observations	320	314	314	314
R-squared	0.0995	0.134	0.093	0.1453

Notes: Robust standard errors are in parenthesis, where *** is significance at the 1% level, ** significance at the 5% level, and * significance at the 10% level.

The analysis of the control variables also provided interesting results. Starting with the climatic variables, we find evidence that average BAR score increases as a function of climate-driven water variability. While this may not be in line with common arguments regarding the links among environmental change, international security, and conflict, it is in line with previous scholarship that has found a robust relationship among water variability, scarcity, and cooperation (Tir and Ackerman, 2009; Dinar et al., 2010). However, similar to the results reflected in Dinar et

al. (2010, 2015), the negative coefficient on the squared CoV term indicates a relationship resembling an inverted U-shaped curve. That is, beyond a certain level of variability the incidence of cooperation begins to decrease and/or the incidence of conflict increases. Thus, the proposition that very high water variability may increase the likelihood of conflict (or at least lower instances of cooperation) is still entirely viable, as high water variability makes it increasingly difficult for riparians to cooperate and honor their treaty commitments.

Two measures were used to proxy for the geographic control a particular riparian has over the basin as well as the control both riparians in the dyad have over the basin, respectively. Two other measures were used to proxy for the importance of the basin to one of the riparians as well as both of the riparians, respectively. Only one of the geographic variables—that is proxying for importance—performed as expected with the other variables being insignificant. In particular, we found that only when the basin was important for one of the riparians, the result was significant and negative. The negative result may be a function of asymmetries in concern for the resource and its utilization (Botteon and Carraro 1997; Ostrom 1992).

Only two of the political and economic controls—democracy and GDP per capita—were significant. Despite the expectations of some studies, democracy seems to have a negative impact on cooperation. Brochmann (2012) finds a very similar result and suggests that most democracies are located in areas where water is not a critical issue and are able to handle their water issues on their own and develop the resource unilaterally. Focusing on Europe, Bernauer and Kuhn (2010) observe that democracy does not necessarily produce equitable international behavior, finding, for instance, that free riding incentives are strong pertaining to river pollution (see also Sigman 2004). Barrett (2003) also challenges the theoretical rational for increased cooperation and participation in environmental agreements among democracies, highlighting cases where non-democracies (rather than democracies) were party to an agreement or more inclined to participate (e.g. Sudan and the Arab Republic of Egypt per the 1959 Nile Water Agreement; USSR Helsinki Protocol [and not the United States and United Kingdom] per the Helsinki Protocol).

As for alliances, one would expect those dyads with some type of military alliance (in this case, entente, nonaggression, neutrality or defense) to also be more prone to cooperation on environmental issues such as water. However, our results did not support this expectation. Instead, our insignificant results may suggest that the two issues (military and the environment) are unrelated so that one does not seem to have an impact on the other. The result may also mirror the

finding of Long and Leeds (2006) who claim that military alliances that are not linked to any specific issue should not be expected to increase cooperation in terms of that issue. (Long and Leeds considered economic issue linkage and impacts on dyadic trade.)

Our results for the power and wealth asymmetries suggest that power asymmetries negatively affect cooperation. This is in line with some of the international negotiation literature, which suggests that power parity is more conducive to cooperation because it reduces mistrust and the fear of cheating, which is more common in asymmetric situations (Rubin and Brown 1975). Song and Whittington (2004), who explore the impacts of power asymmetries (measured as GDP) on cooperation, find that in situations of overwhelming power asymmetry cooperation is negatively affected. Differences in wealth did not seem to make a significant difference. Since wealth asymmetry proxies for the ability of richer states to provide financial incentives to poorer states so as to induce cooperation, the result may not be surprising. A country providing side-payments may be regarded as a weak negotiator and may therefore prefer not to invite such a reputation (Maler 1990: 86). Furthermore, the anticipation of side-payments may provide incentives for strategic behavior by the party that can extract large compensation packages (Maler 1990: 85). Similarly, by providing payment, say, for incentivizing another country to abate pollution, the country providing compensation effectively admits some sort of responsibility for the pollution control even though it was not the main culprit. According to Dombrowsky (2007), side-payments are particularly problematic in international water negotiations as long as the underlying property rights regime is disputed.

Conclusions

Our analysis is couched in recent empirical research, which investigates the general role of treaties in reducing conflict (Tir and Stinnett, 2012; Brochmann, 2012). Our investigation also complements studies that consider the effectiveness of treaties given their design (Dinar et al. 2015; Mitchell and Zawahri 2015; Tir and Stinnett 2011, 2012).

While most basins have no recorded instances of either cooperation or conflict in the BAR database, among those that do, the mere presence of a treaty seems to promote additional cooperation (or reduce conflict) beyond the signing of the treaty itself. Furthermore, the existence of several agreements signed between riparians in a given dyad seems to increase cooperation even

more. This may suggest that while initial agreements signed between river riparians are often insufficient (or too general) to induce sustained cooperation, they create the groundwork for additional treaties (more specific and targeted at a given problem in the basin) that do elicit increased cooperation.

Our results pertaining to our climatic variable suggest that high water variability actually drives states to exhibit cooperative behavior. However, we find that once variability increases beyond a certain threshold, cooperative behavior is negatively affected. Thus, the claim that climate change could have potentially destabilizing effects on international river basins (Intelligence Community Assessment, 2012) is also supported.

Among the various geography variables used, our proxy for basin importance provided telling implications for conflict and cooperation over shared international rivers. In particular, when only one country (in contrast to the other basin riparian in the dyad) deems the basin important, less cooperation ensues. This is telling since the asymmetric level of concern for a natural resource or environmental good (a function of the importance a state attributes to that resource) can very likely generate divergent interests and, thus, conflict.

Among our political and economic variables, democracy and the GDP ratio provided interesting results. Democracy seems to be a detractor to cooperation. As Gerlak and Grant (2009) have conjectured, democracies may also have other avenues of regional cooperation through which they are able to deal with their water issues that are not necessarily a function of formalized treaties. Power asymmetries seem to infringe on the level of cooperation since trust among states is often a function of power parity.

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APPENDIX

Figure A1. Distribution of BAR scores for basins sample (initial treaty signing not included)