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Shared rivers and conflict – A reconsideration

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ABSTRACT

Neomalthusians have regularly predicted "water wars" while cornucopians have argued that there is no inherent water scarcity and liberal institutionalists have seen cooperation as a more likely outcome of competition for limited water resources than violent conflict. Three earlier studies have found a positive statistical relationship between shared rivers and low-level interstate conflict. Based on a more comprehensive dataset, an improved model of conflict, and a more appropriate control for geographical opportunity, we argue that these results are spurious and that we cannot establish a conflict-inducing effect of shared rivers over and beyond contiguity itself. In fact, the new dataset presented here makes it clear that nearly all neighbors in the international system share at least one river. This calls for a different approach to investigating interaction in shared river basins. This notwithstanding, freshwater and other shared resources may still provide a mechanism to explain why contiguity is robustly associated with conflict, so the water-conflict scenario cannot be dismissed. Indeed, our results show that among river-sharing states, basins with an upstream/downstream configuration increase the risk of conflict. The article finally discusses how river interaction should be further investigated based on these results and what new data are needed to enable such research.

Introduction

In a widely cited article, Vasquez (1995) discusses three competing explanations for the robust relationship between contiguity and war. Wars between neighbors may occur because such states have the greatest opportunity to fight, as a result of a higher frequency of overall interaction, or as a result of conflicts of interest over territory. Vasquez favors the territorial explanation (cf. also Holsti, 1991; Huth, 1996). Territory is considered a vital resource in its own right, with symbolic as well as military and economic importance, but it can also harbor other natural resources that may affect states' willingness to fight.

One such resource is freshwater. Among the natural resources featured in the conflict literature, competition for shared water resources holds a prominent place. Although this literature traditionally was dominated by case studies (e.g. Elhance, 1999; Homer-Dixon, 1994, 1999; Lowi, 1995), three large-n studies (Furlong, Gleditsch, & Hegre, 2006; Gleditsch, Furlong, Hegre, Lacina, & Owen, 2006; Toset, Gleditsch, & Hegre, 2000) have expanded general statistical models of interstate war to include a variable assessing whether or not two states share at least one river and find that sharing a river increases the probability that states will experience low-level dyadic conflict. This is consistent with the neomalthusian scenario of violent competition for access to limited freshwater resources. Here we re-examine the river-conflict nexus with an extensively revised and updated dataset of shared rivers, a gravity model of conflict as a baseline, and with proper controls for proximity. We show that it is impossible to disentangle the effect of sharing a river from the effect of being neighbors and that in fact almost all neighboring states in the international system share at least one river. To conclude in favor of a neomalthusian argument about willingness to fight over shared water resources, as the previous studies have done, is premature. The earlier studies may simply capture a contiguity effect. On the other hand, shared water resources may be a mechanism behind the robust association between contiguity and war. We do find, when examining river-sharing dyads only, that dyads with an upstream/downstream relationship along a river have an increased risk of experiencing conflict. We finally discuss what data will be needed to investigate further the possible links between sharing rivers and conflict risk.

Why do neighbors fight?

Interactions between states are shaped by opportunity and willingness (Most & Starr, 1989; Starr, 1978). Opportunity represents the total set of constraints and possibilities available within a given environment. Willingness is the process of choice or the selection of specific behavior by decision makers. Opportunity is

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often operationalized by geographical factors, and specifically by different measures of proximity, notably contiguity, inter-capital distance, or minimum distance (Buhaug & Gleditsch, 2006). Willingness on the other hand has remained a somewhat more elusive concept, measured by such variables as alliances, voting preferences, or democracy (Mitchell & Prins, 1999). However, geographical factors can also shape states' willingness to fight, as argued by Vasquez (1995) and others: Adjacent territory provides states with more than an interaction opportunity. A traditional realist explanation would suggest that neighbors fight more simply because they have the opportunity to do so. States are better able to project force close to home than at long distances (e.g. Boulding, 1962). Alternatively, the higher frequency of war between neighbors may be related to the higher frequency of interaction overall between neighbors. Greater interaction opportunity increases the number of issues of potential disagreement, and some of the disputes are likely to escalate to violence. Finally, the territorial explanation favored by Vasquez argues that it is the value of a state's territory that increases its willingness to go to war. Proximity may provide an opportunity to go to war, but threatened or contested territory also makes state leaders willing to use force. Wars are more common among neighbors than other states because they have territorial disputes (Vasquez, 1995). Besides the intrinsic value of territory, control over territory may secure access to other vital natural resources.

More attentive to the actual interaction and less to systemic factors, researchers with a focus on contentious issues as drivers of international relations argue that state leaders focus on achieving control of specific contentious issues when they engage in interactions with other states (e.g. Diehl, 1992; Hensel, 2001; Hensel, Mitchell, Sowers, & Thyne, 2008; Mansbach & Vasquez, 1981; Mitchell & Hensel, 2007; Mitchell & Prins, 1999). In general the nature of the issue, the degree to which it is tangible or not (e.g. Vasquez, 1983) and its salience (e.g. Hensel, 2001) are typically held as decisive for the nature of inter-state interaction. Furthermore, in order for states to interact over contentious issues, there needs to be an underlying difference of interest warranting some form of adjustment of behavior.

Why would states fight over rivers?

A shared river fits the general characteristics of a possibly contentious issue, and much of the world's freshwater runs in international rivers, transcending regions without regard for national frontiers. Riparian states depend on a relatively fixed amount of water, and thus become highly interdependent. For as many as 39 countries, home to more than 800 million people, at least half of their water resources originate beyond their borders (UNDP, 2006: 210). Egypt, admittedly an extreme case in this respect, is dependent on the Nile for 97% of its water and 95% of the Nile water originates outside Egypt (Gleick, 1993: 86).

Access to sufficient amounts of freshwater is absolutely essential for all aspects of human life and industry, and water has no substitute. Consequently, differing interests emerging over water at the international level are likely to be highly salient issues. Salience, understood as the overall value that is attached to the river by each riparian (Hensel et al., 2008), is thus first and foremost related to the amount of available water relative to the demand on the water source. But, in addition factors such as the navigational value of the river, the degree to which it is used to exploit fish stocks, whether there is a presence some other resource-extraction industry on the river, whether or not there are any hydropower plants along the river, or whether the river is used for irrigation purposes also contribute to river salience (Hensel & Brochmann, 2007; Hensel, Mitchell, & Sowers, 2006). A highly salient river put to multiple uses is likely to stimulate more interaction in general and more conflict in particular (Hensel et al., 2008).

Complicating matters further, river-sharing relationships are inherently asymmetric. Typically, the upstream state is considered to have the upper-hand in river relations since the state with control of the headwaters of a basin has uninterrupted access to the river's water. Any action taken by an upstream state may result in a unidirectional externality for the state downstream, (Barrett, 2003; Bernauer, 2002), i.e. a burden for the downstream state at no cost to the upstream state. As the state furthest downstream on the Nile, Egypt is highly vulnerable to any action taken upstream. This has led Egyptian politicians to make a number of militant statements such as “The only matter that could take Egypt to war again is water” and “the next war in our region will be over water, not politics”.[1] However, asymmetric relations in international river basins do not always favor the upstream state, although that will often be the case where the nature of the contentious issue relates to water quantity or quality (i.e. pollution). As noted, international rivers are also important to riparians because of fish stocks and for navigation. When it comes to navigation, the downstream state can block upstream states from access to important harbors or to the sea, thus limiting their participation in international trade. According to Collier (2007), being landlocked is one of the critical development traps. Thus, navigation issues could potentially reduce the advantage of being an upstream state. Traditionally, navigation was the biggest concern relating to interaction over shared rivers, something that is reflected in the early stages of international water law (Allouche, 2005). Current research on water and conflict is mostly concerned with the water quality and quantity issues relating to freshwater (Tir & Ackerman, 2009). Nevertheless, these different types of potential conflicts illustrate the complexity of river-sharing as a contentious issue in world politics.

As Wolf, Kramer, Carius, and Dabelko (2005: pp. 80–95, 203–206) have argued, however, the modern world has yet to see a large-scale war primarily over water, but some scholars as well as policy makers have warned that such wars are likely to occur, exacerbated especially by population growth and climate change (Bernauer & Siegfried, 2012; Tir & Stinnett, 2012).[2]

In particular, scholars with a neomalthusian view of international affairs argue that shared water resources can become issues of national security if the resource is depleted and becomes scarce due to reduced supply (pollution or reduced water flow), increased demand (resulting from population growth or increased standard of living), or because the resource is unevenly distributed (Homer-Dixon, 1994). Case studies of various river basins (e.g. Elhance, 1999: Homer-Dixon, 1994; Kalpakian, 2004; Lowi, 1995) tend to emphasize the conflict potential in many of the rivers investigated and how water disputes are highly interconnected with other political and socio-economic factors shaping inter-state relations. But still, there is little evidence for the occurrence of “water wars” or even a credible threat of one.

That notwithstanding, wars rarely have a single cause, and water disputes can exacerbate already existing hostilities in a dyad due to the complexity and salience of these issues. It is widely argued, although contested, for instance, that at least part of the cause of the 1967 war in the Middle East was the attempt by members of the Arab League to divert the headwaters of the Jordan River away from Israel (Elhance, 1999; Gleick, 1993). The most recent version of the Pacific Institute's *Water Conflict Chronology* lists 225 historical and on-going instances where water is related to conflict (Gleick, 2010). In most of these disputes, however, water is an instrument of war or a strategic target, rather than a resource at the root of the dispute. Although the number of statistical studies of interaction in international rivers is increasing rapidly (e.g.

Brochmann & Hensel, 2009, 2011; Dinar, 2009; Hensel et al., 2006; Tir & Stinnett, 2012; Yoffe, Wolf, & Giordano, 2003), only three large-n studies have investigated the relationship between sharing a river and the risk of international conflict in general applying traditional models of conflict (Furlong et al., 2006; Gleditsch et al., 2006; Toset et al., 2000). All of them find that river-sharing states have a higher risk of conflict compared to non-river-sharing states *ceteris paribus*. The first, Toset et al. (2000), investigates contiguous dyads for the period 1880–92 and a shorter period 1980–92 based on a list of 214 international rivers recoded into 13,707 contiguous shared-river-dyad-years. In models with standard controls for the risk of conflict, the results show that river-sharing states have more conflict; that the more rivers two states share, the higher the risk of conflict outbreak; and that upstream/downstream dyads have a higher conflict propensity. Since they only investigate contiguous dyads they do not include additional controls for proximity. However, many rivers are missing from their dataset and the models testing the different river configurations are only run for the short time period. Moreover, the upstream/downstream cases are compared to all contiguous dyads instead of all river-sharing dyads, and this undermines the authors' argument that conflict is more likely in upstream/downstream rivers *compared to* rivers with other configurations.

The second article (Furlong et al., 2006) uses mainly the same research design and data, but includes a measure for the length of the land boundary between two states in order to test if the shared-river variable might be a proxy for increased interaction opportunities between states with long, shared borders (because states with long joint borders are more likely to have shared rivers). The boundary length hypothesis does not find general support, but for the short period sharing a river is no longer significant when boundary length is introduced.

The third study (Gleditsch et al., 2006) introduces an improved dataset coded based on river basins[3] rather than single rivers (Owen, Furlong, & Gleditsch, 2004) that includes non-contiguous dyads in the same basin, based on the international river basins provided in the Transboundary Freshwater Dispute Database, TFDD (Wolf, Natharius, Danielson, Ward, & Pender, 1999). This enables the authors to distinguish more clearly between an upstream/downstream relationship and a river-boundary relationship and to test the alternative hypothesis that dyads with a river boundary might have conflicts over disputed territory in the river. However, this hypothesis is not supported. The relationship between sharing a river and dyadic conflict survives another challenge. This study also establishes that the total size of the shared river basin is associated with conflict.

In addition to examining the effect of merely sharing a river, all the three studies focus on water stress in some form. Toset et al. (2000) and Furlong et al. (2006) use a measure for water availability (from Hauge & Ellingsen, 1998), and find that in dyads where one or both of the countries have low water availability, there is a higher risk of conflict but interacting the water availability variable with whether or not states share a river, leads to inconclusive results. Water availability is however only measured as a snapshot, so it does not capture variation over time, or seasonal variation, and it does not take national water demand into account.

Gleditsch et al. (2006) improve the controls for water availability or stress in several ways. First, they include a measure for average rainfall and find that low rainfall increases the risk of conflict, but actually reduces the conflict risk when interacted with shared basin. They also include a variable assessing whether at least one of the countries experienced a drought during the past five years. This variable is never significant. Finally, in addition to examining absolute scarcity, they make a first attempt to assess relative scarcity in a river-sharing dyad, through a measure of the distribution of the water resource, the share of the basin in the upstream state. However, the results in analyses with this variable are inconclusive.[4]

All in all, the impact of scarcity, relative or absolute, on the risk of conflict, remains unclear, mainly due to insufficient data. We acknowledge the need for better data on precipitation and time-varying measures of river discharge or runoff to enable testing the real water availability. Similarly, improved measures for relative scarcity are needed. Both of these will be important contributions to understanding river management, but remain outside the scope of the present project. Furthermore, the lack of consistent findings with respect to scarcity can also be due to the complexity of shared waters discussed above. Water scarcity can be a source of contention in arid regions, but in humid regions water may be a potential source of conflict for other reasons, such as hydropower, fishing, navigation, or pollution. Although overall water availability is likely to affect interaction, this is likely to be especially true when access to the resource is unequal. It is plausible that grievances are particularly likely to occur when one or more states can attribute their own insufficient water access to the use from another riparian that controls more of the resource, or controls it first, and thus have uninterrupted access. Grievances are likely to be reinforced when one's own perceived inadequate access can be blamed on someone else's use (or overuse), and can also be strengthened through deliberate scapegoating from state leaders as diversion acts. The *perceived* level of scarcity is thus the operative term, as it indeed can occur irrespective of whether there actually exists a real scarcity, defined in absolute terms.

In the analyses below we apply several measures to assess water availability and the size of the shared resource, but our main focus in this article is to use the improved data on global river basins to reassess the question of the impact of sharing a river on conflict risk in a dyad.

The Owen et al. (2004) dataset is more complete than the Toset dataset since it includes non-contiguous dyads, but it is still incomplete. First, it leaves out several river basins included in the TFDD river basin database (TFDD, 2010). Second, it turns out that only "relevant non-contiguous dyads" are included based on a somewhat unclear selection criterion (Owen et al., 2004: 14f). The total number of river-sharing dyad-years analyzed in Gleditsch et al. (2006) is thus 16,774 (for the period from 1880 to 2001) compared to 13,707 (1816–1992) in the two earlier studies. Even if there is no evidence of systematic bias in the selection of dyads included, the number of missing dyads is substantial. Ignoring these dyads excludes many potentially relevant river-sharing relationships (such as Egypt and Ethiopia on the Nile and Thailand and China on the Mekong). Furthermore, we argue that as all states within a basin share the same hydrological unit irrespective of whether any water directly crosses the border between two given states, they are likely to face issues of joint management or disputes. For instance, both Slovakia and Slovenia are members of the International Commission for the Protection of the Danube River, but no water runs from one to the other.[5] In this article we introduce a substantially revised and updated dataset where we have recoded all the shared river basins from the TFDD (2010) into a dyadic format, and now have 29,490 river-sharing dyad-years in our analysis in the period 1885–2001.

In addition to insufficient data, there is a problem with the analysis in Gleditsch et al. (2006). The authors conclude that sharing a river increases the chance of conflict even when controlling for contiguity. However, after an initial test with just the control variables (including three measures of proximity – contiguity, length of land boundary, and inter-capital distance – the authors exclude contiguity from the final models. Thus, their final models do not in fact control for contiguity. The length-of-land-boundary variable correlates highly with contiguity ($\rho > 0.7$)

(Gleditsch et al., 2006), but leaving contiguity out is still likely to lead to omitted variable bias. The authors cannot be confident that sharing a river is not a proxy for contiguity.

We re-examine the river-conflict nexus with an improved model that provides proper controls for proximity. We apply a model from Brochmann and Gleditsch (2006). Using the Owen et al. (2004) dataset, these authors find that river-sharing dyads have more cooperation as well as more conflict, in line with the views of Wolf et al. (2005: 80–95, 203–206). The problem noted with the data obviously applies to this study as well. A contribution from this unpublished paper, however, is that it uses the gravity model as a baseline. We adopt the same procedure here, but first describe the new dataset in greater detail.

The new dyadic shared river basin dataset

The new river basin dataset is an extensively revised and updated version of the Owen et al. (2004) dataset. It now includes all river-sharing dyads in the basins included in the Transboundary Freshwater Dispute Database. The new dataset contains a total of 788 river-sharing dyads in 261 river basins compared to 436 in the Owen et al. dataset. The number of basins shared within a dyad ranges from 1 (511 dyads) to 15 (USA and Canada) and 17 basins (Chile and Argentina).

Furthermore, we have improved the coding of the different types of river configurations. In addition to the upstream/downstream dyad and the mixed dyad we now also have a category called the sideways dyad. Upstream/downstream means any dyad where water runs from state A to state B or vice versa, regardless of whether A and B are contiguous or not. For instance, Ethiopia is upstream to Egypt on the Nile although the states are not neighbors. In fact, one of the long-standing disputes on Peter Gleick's water conflict list is between these two countries, following Ethiopian plans for dam construction in the Blue Nile. A mixed relationship is present if country A is both upstream and downstream to country B in the same basin or if the river forms the boundary between two states.[6] Finally, a river relationship is coded as sideways if the two countries each have a share of the river basin, but no water runs from A to B or vice versa.[7] The rationale for including sideways dyads is that conflict or cooperation may occur because countries draw on the same resource, even if they are not in direct bilateral competition with each other. However, we perform separate analyses without the sideways dyads. Although most of these dyads were left out of the Owen et al. dataset, a number of them were included, but erroneously coded as upstream/downstream. The new dataset is available in two formats. First, Version 3.0a is a database containing all river-sharing dyads with separate information on each shared basin. Second, Version 3.0b is in a dyad-year format. Here the data are collapsed into only one row of information per dyad per year irrespective of how many basins they share. This version is thus ready to merge with standard undirected dyad-year datasets. Both datasets are available at our replication site.[8] It is the latter format that will be used in the analysis below. This dataset has the undirected dyad-year as the unit of analysis and covers a time span from 1816 to 2007 (although due to limitations in several of the control variables our analysis here will only cover the period 1885–2001).

Since all information about every river basin shared in a dyad is collapsed into one row in the dataset, a dyad is considered to be upstream/downstream if the same state is upstream in all their shared basins (if they share more than one). If, on the other hand, two states share several basins and A is upstream in one and B in another, we code the dyad as mixed. Among the river-sharing dyad-years in our dataset, 44% are pure upstream/downstream whereas 22% are sideways and the final 34% are in the mixed category.

The gravity model

The gravity model is a useful tool for investigating the effect of sharing a river. The gravity model was developed as a general model of interaction and has been applied to phenomena like migration and inter-city travel (Zipf, 1949) as well as international air travel (Gleditsch 1967 and 1968). It is particularly well established in studies of dyadic trade (Anderson, 1979; Hegre, 2000). Conflict is a form of interaction – the exchange of negative value instead of positive value as in trade – so the gravity model is also a suitable model of conflict (Hegre, 2008). The gravity model asserts that dyadic interaction is proportional to the product of the countries' size and inversely proportional to the distance between them:

$$\text{Interaction}_{ij} = k(\text{Size}_i{*}\text{Size}_j)/\text{Distance}_{ij},$$

where i and j denote the two countries in the dyad. Following most of the relevant literature, we test it as a linear model in logarithmic form. While in the original applications size was measured as population, gravity models of dyadic trade tend to use economic size. Here we include both, in order to take account for differences in wealth. Although including GDP as a measure for economic size is most common, we use GDP per capita since we also include the population measure in the same model. Since GDP per capita is a combination of GDP and population (ln[GDP per capita] = ln[GDP] − ln[population]), including GDP per capita enables us to distinguish better between pure size (populous countries tend to have a high GDP) and level of economic development, or wealth. It also provides for a more straightforward interpretation and we do not lose any information (see Hegre, 2008). Thus, our final gravity model is:

$$\ln I_{ij} = \beta_0 + \beta_1 \ln P_i + \beta_2 \ln P_j + \beta_3 \ln G_i + \beta_4 \ln G_j + \beta_5 \ln D_{ij} + \mu_{ij},$$

where I_{ij} is interaction in the dyad IJ, in our case the risk of conflict between the two states, P_i the population of country I, G_i the GDP per capita of I, and D_{ij} the inter-capital distance between the two countries. The βs are the estimated parameters and μ the unexplained variance. We expect β_3, β_4, and β_5 to have negative signs, since wealth and distance are both negatively associated with conflict.[9] We distinguish between GDP per capita in the smallest economy and in the largest and the population in the largest and smallest country. The data for GDP and population are from Oneal and Russett (2005).

Variables

Dependent variable

Our dependent variable is dichotomous with the value 1 if there is an onset of a militarized interstate dispute with at least one fatality (a" fatal MID") in a dyad in a given year. The data are derived from the Correlates of War Project. MIDs include a wide range of low-level hostilities, so we require at least one fatality, to avoid "attention bias" resulting in overrepresentation of countries with open media (Toset et al., 2000). Years with continued conflict are coded as 0.

Independent variables

As in Gleditsch et al. (2006) we use two independent variables to assess the effect of sharing a river in general: First, we apply a dichotomous variable, *shared basin*, coded as 1 if the two countries in a dyad share at least one river basin and 0 otherwise. Second, as a crude measure of water resources, we include a continuous, log-transformed variable, *basin size*, assessing the total size (in sqkm) of the basin(s) shared by a dyad.

In addition, to investigate the effect of geographical location along the river, we analyze a subset of the data containing river-sharing dyads only, and examine the effect of the upstream/downstream configuration *compared to* other configurations. The variable is named *updown* takes the value of 1 if a dyad has a pure upstream/downstream relationship (see pg. 7) and 0 otherwise. All the river variables are from the new dataset (Brochmann & Gleditsch, 2012).

Control variables

Apart from the control variables contained in the gravity model, we include contiguity as an additional indicator of proximity. Contiguity is coded 1 if the states in the dyad share a land boundary, with data from COW (2012). Buhaug and Gleditsch (2006) found distance to be negatively and significantly related to interstate war even when controlling for contiguity and vice versa. Our analysis confirms that the inclusion of both is crucial for the performance of the shared basin variable.

For comparison with models of international conflict in general (Bremer, 1992), we include two other standard control variables, regime type and the history of peaceful relations in the dyad. *Peace history* is a decay function containing the number of previous years without militarized interstate dispute (MID) in the dyad or the time since the younger of the two countries gained independence.[10] This variable is included as a control for temporal dependence in conflict (Beck, Katz, & Tucker, 1998; Raknerud & Hegre, 1997). Regime type is included by means of four dummy variables with a dyad made up of two democracies as the reference category. These variables originally come from the Polity IV project (Marshall, Jaggers, & Gurr, 2006). We label the variables *One democracy*, *Two autocracies,* and *Unconsolidated regime* depending on the political make-up of the dyad.[11] Democratic peace theory suggests that we should expect double-democratic dyads to have less conflict and politically mixed dyads to have more (Gleditsch & Hegre, 1997). In addition, several authors expect democracies to be better at conserving resources (Li & Reuveny, 2006; Payne, 1995) and for this reason they should be less sensitive to changes in water quality or quantity caused by another state. Democratic upstream states may also be less likely to take actions that harm downstream states (Bernauer & Kuhn, 2010), especially if they also are democratic. Gizelis and Wooden (2010) conclude that democracies are also better able to avoid internal conflicts over water.

Finally, in order to avoid inflating the number of units of analysis, we follow Gleditsch et al. (2006) in limiting the analysis to dyads within the same 'continents',[12] since river basins by definition cannot include countries that are completely separated by ocean.[13] Thus, all single-country islands are also excluded. This reduces the dataset from 636,834 to 113,960 dyad-years (of which 29,490 share rivers). Descriptive statistics are found in Table 1.

Revisiting the river-conflict relationship

One immediate result of the more complete coding of shared-river dyads from the TFDD is that virtually all contiguous countries now have shared rivers. In fact, of all the 299 contiguous dyads in the final year of the dataset (2001), only 17 dyads are without a shared river. This is shown with a cross-tabulation between the shared basin variable and the contiguity variable in Table 2. We list these 17 dyads in Appendix 1 and it is immediately evident that this list is dominated by desert countries and by dyads where at least one of the countries is very small. In fact, we cannot exclude the possibility that all neighboring countries share a river (or more), although some of these rivers may be so small or so seasonal that they fail to get recorded. This result has not been evident from earlier research and calls for a new approach to investigating interaction in international river basins in large-n studies where one also controls for contiguity.

We start with a correlation matrix for shared river and basin size and the two measures for proximity. The results are shown in Table 3. Although most neighbors share rivers there are also many non-contiguous states that do so. Overall the correlation between the variables is not critically high with respect to collinearity problems. Even if running the models with both contiguity and shared basin included does not cause statistical problems, conceptually there will be overlaps in the explanatory power of the two variables. If almost all neighbors share at least one basin, it is impossible to disentangle the effect of being neighbors from the effect of sharing a basin. We discuss the consequences of this further below.

In Table 4 we retest the river-conflict relationship by means of a logistic regression analysis between Shared basin and the onset of a fatal MID controlling for the full gravity model (Model 4.1), the gravity model and controls (4.2), the gravity model without the distance between capitals, but with contiguity (4.3) and, finally, the full gravity model and contiguity (4.4). The remaining control variables are included in Models 2–4.[14] It is evident from these models that it makes sense to apply the gravity model as a baseline for analyzing international conflict. Overall, the gravity variables (size and distance) significantly affect conflict risk. Specifically, dyads with inter-capital distance in the lowest 10th percentile of the sample have almost 100% higher probability of conflict than dyads at mean levels.[15] Similarly, contiguous states have almost 340% higher probability of conflict than non-contiguous states. Size also matters. Populous states have higher conflict risks. States within the 90th percentile of the data have 27% (the largest state in the dyad) and 67% (the smallest state in the dyad) higher probability of conflict than states with population at mean level. Wealth also matters. The probability of conflict increases by 31% if the richest state has a GPD per capita in the 90th percentile rather than

Table 1
Descriptive statistics for all independent and control variables.

Variable	(*n*)	Mean	Std. dev.	Min	Max
Shared basin	113,960	0.26	0.44	0	1
Basin size (ln)	113,960	3.54	6.05	0	16.03
Contiguity	113,960	0.14	0.35	0	1
Distance between capitals (log)	113,939	7.20	0.83	1.61	8.60
GDP per capita, large (log)	103,722	8.38	0.99	5.70	10.74
GDP per capita, small (log)	107,184	7.51	0.92	5.39	10.68
Population, large (log)	113,919	9.82	1.34	3.40	14.05
Population, small (log)	113,942	8.13	1.31	3.14	13.83
Peace history	106,559	−0.10	0.23	−1	−6.94e-18
One democracy	110,361	0.31	0.46	0	1
Two autocracies	107,069	0.28	0.45	0	1
Unconsolidated regime	107,069	0.30	0.46	0	1
Upstream/downstream[a]	29,490	0.43	0.50	0	1

[a] Upstream/downstream is measured for river-sharing states only.

Table 2
Cross-tabulation of shared basin and contiguity.

Shared basin	Contiguity		Total
	0	1	
0	2274	17	2291
1	337	282	619
Total	2611	299	2910

Table 3
Correlation matrix for shared basin, basin size and proximity measures.

	Shared basin	Basin size (log)	Distance between capitals (log)	Contiguity
Shared basin	1.00			
Basin size (log)	0.99	1.00		
Distance between capitals(log)	−0.51	−0.47	1.00	
Contiguity	0.65	0.62	−0.48	1.00

at the mean, whereas it is reduced by 28% with a similar move for the poorest state. The results from the models in Table 4 also show, like we expected, that sharing a river basin is interconnected with being proximate states in the international system, and that these variables overlap. The Shared basin variable is significant in the first three models, but not in Model 4.4. In other words, a fully specified control for proximity (contiguity and inter-capital distance) renders the shared basin variable insignificant.[16]

Table 5 shows similar models run with basin size instead of shared basin as the main dependent variable. Again, when controlling sufficiently for proximity, the size of a shared basin does not significantly affect the risk of conflict in a dyad, as is evident from Model 5.4.[17]

We next ran the same analysis on the post-World War II period (1946–2001) and for the even shorter post-Cold War period (1990–2001). The data for the control variables are more reliable and more complete for the period after World War II, and the "water war" literature frequently argues that we should expect competition for scarce resources to increase with growing population and higher consumption, and particularly after the end of the Cold War where conflict was more focused on ideological dividing-lines. Despite this, the results for the shorter periods are broadly similar. Above all, shared basin and basin size continue to be insignificant with the gravity model and a fully specified control for geographical proximity.

Finally, we ran the analysis with sideways dyads filtered out. These analyses include only dyads that actually exchange water in one direction or another, or both, and thus are more directly affected by actions undertaken by the other riparian in the dyad. In all the eight analyses (for the four models in Tables 4 and 5) the river variables are insignificant once we control for both contiguity and inter-capital distance.

Thus, it is impossible to disentangle the effect of sharing a basin from the effect of proximity in the international system. On the contrary, sharing a basin is an intrinsic part of being neighboring states since almost all neighbors share at least one river basin. Nevertheless, dismissing the possible conflict proneness of international rivers is premature. Sharing a river may be part of what makes territory worth fighting for and thus contribute to the finding that neighbors fight more than other states. We re-ran all the models for contiguous dyads only as a first attempt to address this question. Sharing a basin remains insignificant, but the size of the basin affects whether or not neighbors fight. Among neighbors, the larger the basin the lower the conflict risk.[18] If one accepts that basin size can be a crude proxy for water availability, this finding is in line with a neomalthusian scarcity argument. Water resources are more likely to be fought over where they are less plentiful.[19]

In the following, we investigate river-sharing states only. Specifically, if there are certain aspects of the river that makes states prone to fight, it makes no sense to compare river-sharing states to non-river-sharing states. The latter group of states by definition cannot have features or aspects related to rivers.

Basin size and upstream/downstream configuration

In addition to testing whether river-sharing states have more conflict than other states and examining the possible effect of the size of the basin, the earlier river studies (Furlong et al., 2006; Gleditsch et al., 2006; and Toset et al., 2000) also attempt to examine the effect of geographic location of the states within a river basin. However, as noted, in order to examine the possible effect of an upstream/downstream river configuration *compared to* other river configurations, we should examine river-sharing dyads only. Arguably, this also pertains to the variable measuring basin size. It does not make sense to compare the effect of the size of a basin with dyads that do not share a basin at all. We thus first re-ran all the models in Table 5 for river-sharing states only. In these models, not reported here in the interest of saving space, we found that the size of a basin is negatively related to the risk of conflict.[20] Specifically, in a full model, similar to Model 6.4 below, except that basin size is included instead of upstream/downstream, moving from the mean to the top 95 percentile reduced the probability of conflict by 22%.

Next, to investigate possible effect of the upstream/downstream configuration among riparians, we re-test the models above for river-sharing dyads only with the upstream/downstream configuration as our main independent variable. The results are presented in Table 6. Upstream/downstream dyads have more conflicts than other river-dyads. Specifically, dyads that have pure upstream/downstream relations with respect to their shared river basin(s) have a 48% higher probability of experiencing conflict than other river-sharing dyads.

Table 4
Logistic regression analyses for shared rivers and conflict, controlling for the gravity model and contiguity, all dyads on the same continent, 1885–2001.

	(4.1)	(4.2)	(4.3)	(4.4)
	fMID	fMID	fMID	fMID
Shared basin	1.14 (3.83)***	1.20 (5.43)***	0.89 (3.36)***	0.43 (1.61)
Distance between capitals (log)	−1.00 (3.80)***	−0.80 (5.38)***		−0.61 (4.62)***
Contiguity			1.84 (6.82)***	1.44 (5.48)***
GDP per capita, large (log)	0.14 (0.83)	0.16 (1.26)	0.18 (1.38)	0.20 (1.69)*
GDP per capita, small (log)	−0.60 (3.00)***	−0.250 (1.72)*	−0.17 (1.33)	−0.29 (2.15)**
Population, large (log)	0.23 (2.17)**	0.20 (2.67)***	0.04 (0.53)	0.16 (2.26)**
Population, small (log)	0.50 (5.56)***	0.44 (5.69)***	0.30 (4.37)***	0.38 (5.20)***
Peace history		−2.32 (12.39)***	−2.31 (11.18)***	−2.21 (12.14)***
One democracy		1.84 (5.49)***	1.78 (5.33)***	1.87 (5.66)***
Two autocracies		1.59 (3.69)***	1.29 (3.05)***	1.51 (3.61)***
Unconsolidated regime		1.88 (4.58)***	1.65 (4.10)***	1.84 (4.59)***
Constant	−2.21 (1.04)	−7.69 (4.97)***	−11.46 (10.64)***	−8.32 (6.26)***
Observations	103,427	92,948	92,948	92,948

Robust *z* statistics in parentheses.
*significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5
Logistic regression analyses for basin size and conflict, controlling for the gravity model and contiguity, all dyads on the same continent, 1885–2001.

	(5.1)	(5.2)	(5.3)	(5.4)
	fMID	fMID	fMID	fMID
Basin size (log)	0.06 (2.99)***	0.07 (4.95)***	0.04 (1.90)*	0.02 (0.82)
Distance between capitals (log)	−1.07 (3.69)***	−0.86 (5.31)***		−0.63 (4.69)***
Contiguity			2.12 (6.77)***	1.56 (5.66)***
The control variables in the corresponding models in Table 4 are included, but not reported				
Constant	−1.72 (0.72)	−7.49 (4.52)***	−11.38 (10.47)***	−8.17 (6.02)***
Observations	103,427	92,948	92,948	92,948

Robust *z* statistics in parentheses.
*significant at 10%; *** significant at 1%.

Beyond the results with respect to rivers and the gravity model, our additional control variables also perform as expected, the longer two states have had peaceful relations, the lower the risk of a new conflict erupting (17% lower probability of conflict among countries with the longest peaceful relations compared to the mean), and two democracies have a much lower risk of conflict. If only one of the states in the dyad is democratic or the regimes are unconsolidated the probability of conflict is more than 500% higher than for two democracies. Two autocracies have over 300% higher probability of conflict than two democracies.

Discussion

In this article we have re-investigated the river-conflict nexus. Previous research has argued that river-sharing states have a higher risk of experiencing mutual conflict than other states, but we show the shortcomings of these results. Specifically we show, with substantially revised and updated data on all international river basins, that almost all states in the international system share at least one river basin. When we re-investigate the effect of sharing a river basin on conflict risk with these new data, the gravity model as a baseline and sufficient control for proximity, we find that sharing a basin has no added impact on the risk of conflict outbreak in a dyad. The previous results that have captured such an effect are thus likely to have detected a contiguity effect as it is impossible to disentangle the effect of sharing a river from the effect of being proximate states in the international system.

Nevertheless, it would be premature to reject the argument about the conflict-inducing effect of sharing a river. If Vasquez (1995) is right in interpreting rivalry over territory as the most plausible explanation for the robust relationship between contiguity and war, we still need to establish what aspect of territory is decisive. Is it territorial identity or territory as a resource? If it is a resource, what resource: the land, exploitable raw materials – or water? We find that neighbors do not fight more in general if they share a river, but at the same time, virtually all neighbors do share a river. In fact, sharing a river is inherent in the concept of being neighbors in the international system and it is impossible to disentangle these effects empirically. When we examine river-sharing states only instead of all states, we can uncover whether specific features of rivers make river-sharing relationships more problematic and consequently contributes to increase the risk of conflict between these states. In a first cut, we do indeed find that the upstream/downstream configuration increases the risk of conflict among these states.

We thus call for a different approach to the study of interaction in international river basins. First, the geographical finding here indicates that it matters *how* a river basin is shared. Structural scarcity may be at least as important for conflict risk as absolute scarcity. In fact, Elhance (1999: 4) argues that scarcity in itself is not likely to lead to conflict, but it is when an essential resource such as freshwater is "…rightly or wrongly perceived as being over-exploited or degraded by others at a cost to oneself, that states may become prone to conflict". In the same spirit, we suggest giving more attention to the importance of rivers beyond the question of the quantity of water, e.g. in relation to fishing, navigation, and hydropower generation.

Although the present dataset based on the TFDD dataset should be nearly 100% complete,[21] it cannot resolve fully the issue of whether contiguity merely provides an opportunity factor for conflict, or whether it also plays a role in determining the motive (or willingness) for war, as Vasquez assumes. We might surmise that the length of the land boundary could work as a proxy for the importance of territory generally, but when we introduce it into our models here, it does not eliminate the influence of contiguity.

Three paths seem particularly promising in further research on this topic: One is to look to issue coding of conflict for indications that disagreements over the sharing of water resources is the stated object of the conflict. Studying international river claims (explicit disagreements over the use of rivers at an official level), Hensel and Brochmann (2007) find that water scarcity and greater demands on water increase the risk of onset of such claims as well as the risk that they militarize. Yet they also find that although the existence of a river treaty among the riparians does not prevent future water disagreements, states are more likely to enter into negotiations to

Table 6
Upstream/downstream configuration and conflict risk, controlling for the gravity model and contiguity, all river-sharing dyads, 1885–2001.

	(6.1)	(6.2)	(6.3)	(6.4)
	fMID	fMID	fMID	fMID
Upstream/downstream	0.79 (2.64)***	0.32 (1.44)	0.42 (1.89)*	0.38 (1.80)*
Distance between capitals (log)	−0.97 (4.03)***	−0.76 (5.07)***		−0.54 (3.93)***
Contiguity			1.74(6.63)***	1.40 (5.31)***
The control variables in the corresponding models in Table 4 are included, but not reported				
Constant	−0.79 (0.42)	−5.08 (3.04)***	−8.70 (7.13)***	−6.48 (4.54)***
Observations	25,483	23,253	23,253	23,253

Robust *z* statistics in parentheses.
*significant at 10%; *** significant at 1%.

resolve these disagreements if there is a treaty in place (Brochmann & Hensel, 2009). A weakness of issue coding is, of course, that statements about the nature of the conflict may not reflect the 'true' intentions of the parties. A second level of issue coding may perhaps be performed when declassified state records and memoirs become available, but for the moment issue coders are limited to contemporaneous statements by decision-makers and observers of the conflict.

A second path is to continue to develop better measures for water availability and river salience. Here we apply very crude measures to get at river importance and water availability but continuing to improve the quality of time-varying hydrological data will improve the assessment of the impact of water availability and demand immensely. The larger the hydrological size of the basin, the more important it is as a resource for fishing, for navigation, and for hydroelectric power. Attempts to limit this resource may be a source of conflict, regardless of whether the downstream country is facing water scarcity in an absolute sense. For instance, Bernauer and Siegfried (2012) apply hydrological data to a study of potential conflict in the Syr Daria basin in Central Asia. Beyond water quantity, river salience in a broader sense should be incorporated into the analyses. Here, case studies from various basins should lead the way and attempt to uncover which mechanisms may drive river interaction. The ICOW (2012) river basins dataset applies an index measuring overall river salience, and although an admirable first step, more in-depth knowledge of features driving river interaction is warranted.

Third, more insight can be gained from a closer look at the asymmetries between upstream and downstream countries. In addition to the pure geographical asymmetries inherent in the upstream/downstream configuration, asymmetries in control of the resource are likely to affect interaction patterns, especially in combination with political asymmetries in general.

Appendix 1. Contiguous dyads that do not share a river

State A	State B
Mauritania	Morocco
Mauritania	Algeria
Djibouti	Eritrea
Tunisia	Libya
France	Monaco
Libya	Egypt
Italy	San Marino
Iraq	Kuwait
Saudi Arabia	Yemen
Saudi Arabia	Kuwait
Saudi Arabia	Qatar
Saudi Arabia	United Arab Emirates
Saudi Arabia	Oman
Yemen	Oman
Qatar	United Arab Emirates
United Arab Emirates	Oman
Malaysia	Singapore

Endnotes

[1] Statement respectively by the then President Anwar Sadat in 1979 and the then Foreign Minister Boutros Boutros-Ghali in 1988, according to Gleick (1993: 86).

[2] However, the argument that water wars are unlikely has also been made by a number of authors (e.g. Beaumont, 1997; Katz, 2011; Wolf et al., 2005; and Yoffe et al., 2003).

[3] An international river basin is defined as "… all the land that that drains through a given river and its tributaries into an ocean or an internal lake or sea and includes the territory of more than one country" (Yoffe et al., 2003: 1110).

[4] They run this variable in the models both as an absolute measure and as percentage of the total basin size. As only the absolute term is significant in the models this is likely to capture a size effect of the basin rather than unequal distribution. Furthermore, the dataset codes only the size of the largest basin if the states share more than one. If two river-sharing states are upstream on different rivers, the unequal distribution is not captured. Finally, instead of comparing river-sharing dyads only, they include all dyads. This makes it difficult to draw any conclusions about the effect of an uneven distribution compared to states with a more equal river distribution.

[5] Cf. www.icpdr.org/icpdr-pages/countries.htm, downloaded 25 November 2011.

[6] For instance, a stretch of the Rhine forms the boundary between France and Germany.

[7] As noted above, Slovenia and Slovakia are located "sideways" in the Danube.

[8] For more details about the data and coding procedures, see the codebook (Brochmann & Gleditsch, 2012).

[9] Although with respect to wealth the opposite argument can also been made as wealthier states will have more money to allocate to the military and thus increased ability to project force (Gartzke, 2007; Kennedy, 1988).

[10] The variable is defined as $-(2\cdot(-\text{years of peace})/\alpha)$ where α is a half–life parameter. We choose $\alpha = 2$ as we assume the conflict increasing effect of a previous conflict to be halved every second year (see Gleditsch et al., 2006: 14, fn. 12).

[11] For a dyad to be labeled one democracy, one of the countries has to have a value of 6 or higher on the Polity scale. In Two autocracies, both countries have −−6 or lower. In unconsolidated dyads at least one of the countries has a value between −−5 and 5 and the other has 5 or less.

[12] Eight "continents" are coded: *North America* (all countries from Panama and northwards), South America (all countries from Colombia and southwards), *Hispaniola* (Haiti and Dominican Republic), Africa (including Egypt), United Kingdom and Ireland, Western Eurasia (includes Russia, Armenia, Azerbaijan, Georgia and Turkey and all European countries further west), Eastern Eurasia (includes Russia, Armenia, Azerbaijan, Georgia and Turkey and all countries further east), and *Indonesia* (with two islands shared by several countries, Borneo and New Guinea – leaving out Timor, since East Timor did not become independent until 2002). Cyprus might have been coded as continent no. 9. However, the Turkish Republic of Northern Cyprus, de facto independent since 1983 is not recognized by any country other than Turkey. If North Cyprus is coded as Turkey, Turkey becomes part of three continents. We have solved this problem by eliminating Cyprus from our dataset, i.e. treating it as a single-nation island.

[13] The analyses are also run for all dyads, but the results do not differ significantly.

[14] All the final models are estimated with robust standard errors clustered on country dyads.

[15] Marginal effects are calculated using the Clarify software (Tomz, Wittenberg, & King, 2003) for a specific interval on the independent variables' values while holding the other variables constant. The baseline value is set to be the variable's mean if it is a continuous variable and 0 if it is dichotomous. The interval extends from the baseline and to the 90th or the 10th percentile for the continuous variables and from 0 to 1 for the dummies.

[16] We also ran a fixed-effects model to control for dyad-specific factors, but sharing a basin remained insignificant.

[17] Although not reported, all models in Table 4 are run with the same controls as the corresponding model in Table 3.

[18] The results of these analyses are not reported here, but will be made available through the replication do file upon publication.

[19] However, the geographical size of a basin is at best, a very crude measure for water availability. Research on the effects of climate change frequently uses rainfall to assess possible scarcity, as did Gleditsch et al. (2006). They also applied a measure of drought. We re-ran our analyses with the measures of average rainfall and drought and found that whereas whether or not there has been a drought in the dyad does not matter for conflict risk, less rain increases the risk of conflict. The conflict-inducing effect of low rainfall seems to be mediated somewhat if the countries in the dyad share a river basin, as an interaction term between sharing a river and rainfall is positive. Thus, low rainfall has a conflict-inducing effect mainly in states that *do not* share a river.

[20] The full analysis can be obtained from the replication file posted at www.prio.no/cscw/datasets.

[21] As pointed out by Gleditsch et al. (2006: 366, fn. 2) a few small boundary-crossing rivers in Europe are missing in TFDD, for instance between Norway and Sweden, but there is no reason to believe that this affects our results.

References

Allouche, J. (2005). *Water nationalism: An explanation of the past and present conflicts in Central Asia, the Middle East and the Indian subcontinent*. PhD dissertation, University of Geneva.

Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *American Economic Review, 69*(1), 106–116.

Barrett, S. (2003). *Environment and statecraft: The strategy of environmental treaty-making*. Oxford: Oxford University Press.

Beaumont, P. (1997). Water and armed conflict in the Middle East – fantasy or reality? In N. P. Gleditsch, et al. (Eds.), *Conflict and the environment* (pp. 355–374) London: Kluwer Academic.

Beck, N., Katz, J. N., & Tucker, R. (1998). Taking time seriously: time-series-cross-section analysis with a binary dependent variable. *American Journal of Political Science, 42*(4), 1260–1288.

Bernauer, T. (2002). Explaining success and failure in international river management. *Aquatic Sciences, 64*(1), 1–19.

Bernauer, T., & Kuhn, P. M. (2010). Is there an environmental version of the Kantian peace? Insights from water pollution in Europe. *European Journal of International Relations, 16*(1), 77–102.

Bernauer, T., & Siegfried, T. (2012). Climate change and international water conflict in Central Asia. *Journal of Peace Research, 49*(1), 227–239.

Boulding, K. (1962). *Conflict and defense*. New York: Harper and Row.

Bremer, S. (1992). Dangerous dyads: conditions affecting the likelihood of interstate war, 1816–1965. *Journal of Conflict Resolution, 36*(2), 309–341.

Brochmann, M., & Gleditsch, N. P. (2006). Shared rivers and international cooperation. Paper presented at the 47th Annual Convention of the International Studies Association, San Diego, CA, 22–26 March and the workshop "Polarization and conflict, " Nicosia, Cyprus, 26–29 April.

Brochmann, M., & Gleditsch, N. P. (2012). *Codebook for the revised shared river dataset*. Oslo: PRIO. www.prio.no/cscw/datasets.

Brochmann, M., & Hensel, P. R. (2009). Peaceful management of international river claims. *International Negotiation, 14*(2), 391–416.

Brochmann, M., & Hensel, P. R. (2011). The effectiveness of negotiations over international river claims. *International Studies Quarterly, 55*(3), 859–882.

Buhaug, H., & Gleditsch, N. P. (2006). The death of distance? the globalization of armed conflict. In M. Kahler, & B. Walter (Eds.), *Territoriality and conflict in an era of globalization* (pp. 187–216). Cambridge: Cambridge University Press.

Collier, P. (2007). *The bottom billion: Why the poorest countries are failing and what can be done about it*. Oxford: Oxford University Press.

COW. (2012). *Direct contiguity, 1816–2006 (v3.1)*. www.correlatesofwar.org.

Diehl, P. F. (1992). What are they fighting for? The importance of issues in international conflict research. *Journal of Peace Research, 29*(3), 333–344.

Dinar, S. (2009). Scarcity and cooperation along international rivers. *Global Environmental Politics, 9*(1), 109–135.

Elhance, A. P. (1999). *Hydropolitics in the 3rd world. Conflict and cooperation in international river basins*. Washington, DC: United States Institute of Peace Press.

Furlong, K., Gleditsch, N. P., & Hegre, H. (2006). Geographic opportunity and neomalthusian willingness: boundaries, shared rivers and conflict. *International Interactions, 32*(1), 1–30.

Gartzke, E. (2007). The capitalist peace. *American Journal of Political Science, 51*(1), 166–191.

Gizelis, T.-I., & Wooden, A. E. (2010). Water resources, institutions, and intrastate conflict. *Political Geography, 29*(8), 444–453.

Gleditsch, N. P. (1967). Trends in world airline patterns. *Journal of Peace Research, 4*(4), 366–408.

Gleditsch, N. P. (1968). The international airline network: a test of the Zipf and Stouffer hypotheses. *Papers, Peace Research Society (International), 9*, 123–153.

Gleditsch, N. P., Furlong, K., Hegre, H., Lacina, B., & Owen, T. (2006). Conflicts over shared rivers: resource scarcity or fuzzy boundaries? *Political Geography, 25*(4), 361–382.

Gleditsch, N. P., & Hegre, H. (1997). Peace and democracy: three levels of analysis. *Journal of Conflict Resolution, 41*(2), 283–310.

Gleick, P. H. (1993). Water and conflict, fresh water resources and international security. *International Security, 18*(1), 79–112.

Gleick, P. (2010). *Water conflict chronology*. Oakland, CA: Pacific Institute, Last updated 2010. Last accessed 27.10.11. www.worldwater.org/conflict/list/.

Hauge, W., & Ellingsen, T. (1998). Beyond environmental scarcity: causal pathways to conflict. *Journal of Peace Research, 35*(3), 299–317.

Hegre, H. (2000). Development and the liberal peace: what does it take to be a trading state? *Journal of Peace Research, 37*(1), 5–30.

Hegre, H. (2008). Gravitating toward war – preponderance may pacify, but power kills. *Journal of Conflict Resolution, 52*(4), 566–589.

Hensel, P. R. (2001). Contentious issues and world politics: the management of territorial claims in the Americas, 1816–1992. *International Studies Quarterly, 45*(1), 81–109.

Hensel, P. R., & Brochmann, M. (2007). Armed conflict over international rivers: the onset and militarization of river claims. Paper presented at the 48th Annual Convention of the International Studies Association, Chicago, IL, 28 February–3 March.

Hensel, P., Mitchell, S., & Sowers, T. E., II (2006). Conflict management of riparian disputes. *Political Geography, 25*(4), 383–411.

Hensel, P. R., Mitchell, S. M., Sowers, T. E., II, & Thyne, C. L. (2008). Bones of contention: comparing territorial, maritime and river issues. *Journal of Conflict Resolution, 52*(1), 117–143.

Holsti, K. J. (1991). *Peace and war: Armed conflicts and international order 1648–1989*. Cambridge: Cambridge University Press.

Homer-Dixon, T. F. (1994). Environmental scarcities and violent conflict: evidence from cases. *International Security, 19*(1), 5–40.

Homer-Dixon, T. F. (1999). *Environment, scarcity and violence*. Princeton, NJ: Princeton University Press.

Huth, P. (1996). *Standing your ground. Territorial disputes and international conflict*. Ann Arbor, MI: University of Michigan Press.

ICOW. (2012). *Issue Correlates of War Project*. www.paulhensel.org/icow.html.

Kalpakian, J. (2004). *Identity, conflict and cooperation in international river systems*. Aldershot: Ashgate.

Katz, D. (2011). Hydro-political hyperbole: examining incentives for overemphasizing the risks of water wars. *Global Environmental Politics, 11*(1), 12–35.

Kennedy, P. (1988). *The rise and fall of the great powers. Economic change and military conflict from 1500 to 2000*. London: Unwin Hyman.

Li, Q., & Reuveny, R. (2006). Democracy and environmental degradation. *International Studies Quarterly, 50*(4), 935–956.

Lowi, M. R. (1995). Rivers of conflict, rivers of peace. *Journal of International Affairs, 49*(1), 123–145.

Mansbach, R., & Vasquez, J. (1981). *In search of theory: A new paradigm for global politics*. New York: Columbia University Press.

Marshall, M. G., Jaggers, K., & Gurr, T. R. (2006). *Polity IV project: Political regime characteristics and transitions, 1800–2004*. Vienna, VA: Center for Systemic Peace, Updated versions available at http://www.systemicpeace.org/polity/polity4.htm.

Mitchell, S. M., & Hensel, P. R. (2007). International institutions and compliance with agreements. *American Journal of Political Science, 51*(4), 721–737.

Mitchell, S. M., & Prins, B. C. (1999). Beyond territorial contiguity: issues at stake in democratic militarized interstate disputes. *International Studies Quarterly, 43*(1), 169–183.

Most, B. A., & Starr, H. (1989). *Inquiry, logic, and international politics*. Columbia, SC: University of South Carolina.

Oneal, J. R., & Russett, B. (2005). Rule of three, let it be? When more really is better. *Conflict Management and Peace Science, 22*(4), 293–310.

Owen, T., Furlong, K., & Gleditsch, N. P. (2004). *Codebook for the shared river basin GIS and database*. Oslo: PRIO. www.prio.no/sptrans/-1045691924/Codebook%20for%20The%20Shared%20River%20Basin%20GIS%20and%20Database.pdf.

Payne, R. A. (1995). Freedom and the environment. *Journal of Democracy, 6*(3), 41–55.

Raknerud, A., & Hegre, H. (1997). The hazard of war: reassessing the evidence for the democratic peace. *Journal of Peace Research, 34*(4), 385–404.

Starr, H. (1978). Opportunity and willingness as ordering concepts in the study of war. *International Interactions, 4*(4), 363–387.

TFDD. (2010). *The Transboundary Freshwater Dispute Database*. Corvallis, OR: University of Oregon. www.transboundarywaters.orst.edu/database/ Last accessed 04.11.12.

Tir, J., & Ackerman, J. T. (2009). Politics of formalized river cooperation. *Journal of Peace Research, 46*(5), 623–640.

Tir, J., & Stinnett, D. M. (2012). Weathering climate change: can institutions mitigate international water conflict? *Journal of Peace Research, 49*(1), 211–225.

Tomz, M., Wittenberg, J., & King, G. (2003). *Clarify: Software for interpreting and presenting statistical results*. www.stanford.edu/~tomz/software/clarify.pdf Last accessed 01.11.11.

Toset, H. P. W., Gleditsch, N. P., & Hegre, H. (2000). Shared rivers and interstate conflict. *Political Geography, 19*(6), 971–996.

UNDP. (2006). *Human development report 2006*. Houndsmill: Palgrave Macmillan, for the United Nations Development Programme. http://hdr.undp.org/hdr2006/.

Vasquez, J. A. (1983). The tangibility of issues and global conflict: a test of Rosenau's issue area typology. *Journal of Peace Research, 20*(2), 179–192.

Vasquez, J. (1995). Why do neighbors fight? Proximity, interaction, or territoriality. *Journal of Peace Research, 32*(3), 277–293.

Wolf, A. T., Natharius, J. A., Danielson, J. J., Ward, B. S., & Pender, J. K. (1999). International river basins of the world. *International Journal of Water Resources Development, 15*(4), 387–427.

Wolf, A. T., Kramer, A., Carius, A., & Dabelko, G. (2005). *Managing water conflict and cooperation*. Ch. 5 in Redefining global security. The state of the world report. Washington, DC: Worldwatch Institute.

Yoffe, S., Wolf, A. T., & Giordano, M. (2003). Conflict and cooperation over international freshwater resources: indicators of basins at risk. *Journal of American Water Resources Association, 39*(5), 1109–1126.

Zipf, G. K. (1949). *Human behavior and the principle of least effort*. Cambridge, MA: Addison-Wesley.