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Shared rivers and interstate conflict☆

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Abstract

"The previous war in the Middle East was about oil, the next war will be about water." Such predictions have been made regularly, and particularly with reference to the possibility of upstream–downstream conflicts in major rivers which cross interstate boundaries. A good case can be made that competition over water resources may exacerbate conflict and contribute to interstate violence. More than 200 river systems are shared by two or more countries. Many rivers run between countries with a history of conflict, where water plays an important part

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in the economic life of the country. The dramatic statements about 'water wars', however, have a weaker foundation. As resource optimists have pointed out, there is an abundance of water where it is not subject to wasteful uses, human ingenuity can overcome water shortages, and nations can cooperate rather than fight to resolve international water issues. This study is built on newly generated data on boundary-crossing rivers, which have been added to the Correlates of War contiguity dataset. Our results indicate that a joint river does indeed increase the probability of militarized disputes and armed conflict over and above mere contiguity. This risk factor is comparable in size to standard control variables, but much smaller than the effect of contiguity itself. Water scarcity is also associated with conflict, and the upstream/downstream relationship appears to be the form of shared river most frequently associated with conflict. But these results are not very strong and we do not have any systematic data on the issues involved in the shared-river conflicts.

Keywords: Rivers; Conflict; Environment

Water and human security

Water is an essential commodity for human existence. Water is used for consumption, for maintaining public health, for agriculture, for industry, and for transportation. Serious scarcities of water will affect virtually every aspect of human life. Given the importance of water, it is not surprising that water is expected to be among the commodities which people will be especially concerned to preserve, even to the point of fighting. For a country heavily dependent on river water for its economic development, the threat of having its water supply severely constrained by an upstream user may seem threatening indeed.

Indeed, the idea of 'water wars' has become part of the political rhetoric. As early as 1967, just before the Six-Day War between Israel and its Arab neighbors, Prime Minister Levi Eshkol declared that "water is a question of survival for Israel", and therefore "Israel will use all means necessary to secure that the water continues to flow" (Biliouri, 1997, p. 5). In the mid-1980s, US intelligence services are said to have "estimated that there were at least ten places in the world where war could break out over dwindling shared water" (Starr, 1991, p. 17). In 1991 the then Crown Prince of Jordan is reported to have said that the 1967 war "was brought on very largely over water related matters" and that unless there was an interstate water agreement in the Middle East by 2000 "countries in the region will be forced into conflict" (cited from Irani, 1991, pp. 24, 25). At the Habitat conference in Istanbul in 1996, the Secretary-General of the Conference was reported to have told the participants that "the scarcity of water is replacing oil as a flashpoint for conflict between nations in an increasingly urbanized world" (cited from Lonergan, 1997, p. 375). More recently, Hilde Frafjord Johnson, then Norwegian Minister of Development and Human Rights, argued that in many countries water shortages could develop into major conflicts (interview in *Dagbladet*, 20 August 1998). The media have reported numerous similar statements by politicians, spokespersons for international organizations, and others.

More tempered fears have been expressed by, for instance, Elhance (1999, p. 4), who argues that an unequal distribution of freshwater does not in itself necessarily lead to acute interstate conflict, but that “severe scarcities of *an essential, non-substitutable, and shared resource*” like freshwater may make states prone to conflict. Dupont (1998, p. 73), who views environmental security as an important issue in the Asia–Pacific region, believes that “environmental issues are unlikely to be the primary cause of a major conflict between states”. He takes a middle ground in concluding that water wars are less likely between countries “with shared values and generally cooperative relations”. Trolldalen (1992, p. 61) asserts that “Competition for both quality and quantity of shared water at a local level often leads to international water conflicts”, but he does not specify that such conflicts are necessarily violent. Homer-Dixon (1999, pp. 179–180) argues that although there have been a number of resources wars over non-renewable resources like oil and minerals, there are few examples of wars over renewable resources. Among the renewables, Homer-Dixon believes that water is the most likely candidate for stimulating international war. However, wars over river water are likely to take place only under special conditions such as high dependence on water in a downstream country, a history of antagonism between the two countries, and so on.

Resources and conflict

Most conflicts are over scarce resources of one kind or another, at least if territory is counted as a scarce resource. Holsti (1991, p. 307) concluded that among interstate wars in the period 1648–1989, territory was by far the single most important issue category. In the first period such issues figured in about half the wars, declining to about one-third in the post-World War II period. In a reanalysis, Vasquez (1993, p. 130; 1995, p. 284) found that between 79% and 93% of all wars over Holsti’s five time-periods involved territory-related issues. Huth (1996, p. 5), in a study of territorial disputes in 1950–90, characterized this issue as “one of the enduring features of international politics”. This relationship holds for interstate as well as intrastate conflict. Wallensteen and Sollenberg (2000) found that among the 110 conflicts in 73 countries in the post-Cold War period (1989–99)—the vast majority of which were intrastate conflicts—over half were over territory, the rest over government. The territorial explanation for war is also consistent with the finding that wars occur most frequently between neighbors (Bremer, 1992) and between proximate countries (Gleditsch, 1995). There is still some dispute whether wars between neighbors occur mainly because they fight over territory or because they generate disagreements in their day-to-day interaction, or because they are more easily available for fights—but Vasquez (1995) has presented a strong case for the territorial explanation.

But what is it about territory that makes it worth fighting for? Territory can be a symbol of self-determination and national identity, but it can also be a proxy for tangible resources found on the territory. Such resources are *strategic raw materials*, *sources of energy*, *food*, and—emerging strongly in the public debate—*access to freshwater resources*.

The hypothesis that scarce resources create conflict is closely related to the debate about environmental conflict (Gleditsch, 1997). Many social scientists, such as Bächler et al. (1996) and Homer-Dixon (1991, 1999), have posited that environmental degradation depletes the stock of scarce resources, so that resource conflicts are generated or exacerbated in new areas and for resources that previously were plentiful. Others, in a new wave of writing on economic motives for war (Collier, 2000; de Soysa, 2000), maintain that resource abundance may provide a motive for loot-seeking, a factor in many violent civil conflicts in Africa.

In this article we do not address directly either the environmental issue or the question of loot-seeking behavior in conflict. We simply set out to study how the supply of a specific resource, water, may be associated with violent conflict between states, on its own or in interaction with other factors.

Water—a renewable resource?[2]

Most writing on water conflict focuses on water scarcity. But is there a scarcity of water? The total amount of water on earth has been calculated at 1650 mill. km^3, or more than 0.25 km^3 per person. Unlike non-renewable resources such as petroleum, water is rarely consumed in the sense of becoming unavailable for use by human beings. Rather, it circulates in a never-ending hydrological cycle, which regularly cleans and desalinates the water by evaporation and precipitation.

But there is also bad news: 97% of the water is unusable for human consumption as saltwater and only 3% is freshwater. A total of 87% of the freshwater is not directly available, either because it is locked up in icecaps or in deep aquifers, or because it is polluted. Water has to be regarded as a finite and fixed resource, and the rise of the global population has progressively reduced the world run-off per capita, from 40,000 m^3 per person in 1800 to 6840 m^3 in 1995, estimated to fall further to 4692 m^3 by 2025. Water resources are enormously skewed geographically. North America has an annual run-off of 17,000 m^3 per capita per year, while Africa has 6000, and Egypt has 50. Less than 1% of all the world's usable freshwater is found in the Middle East or North Africa, although this region contains 5% of the world's population. Many countries with lower water availability today, particularly in Africa, also have high rates of population growth, so that their water shortages may be exacerbated in the future. Increasing standards of living may lead to greater demands for water. In a study for the International Water Management Institute, Seckler, Molden and Barker (1998, p. 1) estimate that "slightly more than one billion people live in arid regions that will face absolute water scarcity by 2025". In particular, they see groundwater depletion and pollution "as a major threat to food security in the coming century". The existing demand for water exceeded the renewable sup-

[2] In addition to specific sources cited in the text, this section relies on Beaumont (1997), Falkenmark (1990), Shiklomanov (1993), and *Aschehoug og Gyldendals Store Norske Leksikon* (1989). There are many definitional problems, including whether water availability should be measured as precipitation or runoff.

ply for half a dozen countries in the late 1980s and more countries will move into this category. Lundqvist (1998, p. 428) fears impending "hydrocide", where pollution and heavy water withdrawals will cause disease, ecosystem disturbance, and societal disorder. Many countries are highly dependent on water that originates outside their border—over 90% in the case of countries like Egypt, Hungary, and Mauritania (Gleick, 1993a, pp. 100, 103–104).

Very little water is needed for vital human life processes. A person requires perhaps 1–2 m^3 of drinking water per year, a minuscule amount compared to what is available even in many arid countries. More water is required for the transportation of urban or industrial wastes. Counting these uses, as well as normal inefficiencies and losses, the annual freshwater needed for urban life has been estimated at about 250 m^3 per capita, a much higher figure but still low compared even to the projected availability of 4692 m^3 in 2025. Even though urban and industrial uses of water can be quite wasteful, few countries would experience severe water shortages if this were the end of the story. Although there are many problems of interpretation and measurement, the overall message seems clear: there is no scarcity of water for the globe as a whole. However, many areas have water shortages relative to their present needs, and this problem may increase unless changes are made in the patterns of supply or consumption. Securing adequate and plentiful water for human objectives is a political and economic issue rather than one of absolute physical constraints.

The question of water as a lootable resource has not been given comparable attention in the water conflict literature. However, an abundance of water can stimulate transportation on the waterways, facilitate the disposal of waste, and generate other exploitable resources, like fishing and hydroelectric power. Once again, it seems probable that other factors than the absolute amount of water available will decide whether such exploitation follows a violent or a peaceful track.

Water conflicts

Based in part on the optimistic and the pessimistic aspects of the resource situation, two different scenarios may be outlined. The *conflict scenario* foresees growing and increasingly serious water scarcities in a number of countries. "Where water is scarce, competition for limited supplies can lead nations to see access to water as a matter of national security" (Gleick, 1993a, p. 79). The current trends in population and development will make water "an increasingly salient element of interstate politics, including violent conflict" (Gleick, 1993a, p. 79). In order to identify potential trouble areas we need to look to "rivers, lakes, and water aquifers shared by two or more nations" (Gleick, 1993a, p. 80). While flowing in its natural course, a transboundary river does not necessarily follow state boundaries. To overcome food scarcity and poverty, an upstream country might be tempted to use the water to increase its biomass production in agriculture and forestry. Such use (or misuse) can affect the quantity and quality of water sent to the downstream neighbor. In particular, there is a "serious risk of international conflict", especially in the Middle East and Africa, "between upstream and downstream countries" (Falkenmark, 1990, p. 179).[3]

The *cooperation scenario*, while freely admitting the possibility of conflict, denies its inevitability (Kukk & Deese, 1996, p. 51; Lowi, 1995, p. 123; Rogers, 1996, p. 511).[4] As noted above, all countries have access to a sufficient amount of drinking water. Irrigation makes the most severe demands on freshwater supplies, and even a small concentration of salt progressively worsens the soil quality, requiring ever more water per hectare. In Egypt, it takes about 3000 tons of water to produce a ton of wheat. Most of this water is wasted in evaporation. What goes up, must come down, but not necessarily in the same area. When viewed in a global perspective, producing more food in areas where water was more plentiful might conserve water. This would require less self-sufficiency and more international trade, but such policies are controversial for a variety of reasons.

The cooperation scenario further points to the possibility of cooperative arrangements for sharing river resources between the upstream and downstream countries, including treaties and joint river administrations. Such arrangements have been in force on the Danube[5] and the Rhine for decades. Even the Mekong River Basin has had a UN-sponsored committee in operation since 1957, but the long and numerous Indochina wars prevented the body from making much progress (Dupont, 1998, p. 71). In April 1995, Cambodia, Laos, Thailand, and Vietnam did, however, sign an agreement establishing the Mekong River Commission, whose mandate calls for cooperation in the management and conservation of water resources in the river basin, including irrigation, hydropower, navigation, flood control, fisheries, timber floating, and tourism. In fact, the Mekong River Commission is a better example of how an ideologically driven armed conflict prevents cooperation in the development of shared water resources than an example of how a shared river generates conflict among the riparian states.[6] Another example of how water shortage may lead to cooperation rather than armed conflict is provided by the example of the island state of Singapore, which relies on neighboring Malaysia for about 50% of its water needs. Singapore's water is supplied under two agreements, signed in 1961–62, which expire in 2011 and 2061 respectively (Dupont, 1998, p. 67). While increased use of water in both countries may lead to haggling over the terms of these agreements when they run out, armed conflict does not seem very likely. As part of NAFTA, the US and Mexico have established a Border Environmental Cooperation Commission, which among other things deals with transboundary river issues over a border exceeding 3000 km (Milich & Varady, 1999, pp. 287–306).

[3] A number of other examples are cited by Wolf (1999b, p. 243).

[4] All the figures in this paragraph are from Beaumont (1997).

[5] The Danube is by a wide margin the river shared by most countries (19). Next on the list are the Congo and the Niger (shared by 11) (Wolf et al., 1999, p. 424).

[6] The members have also engaged in talks with China and Myanmar (Chou, 1998, p. 5). However, China, which is upstream to all the other riparian states (the Mekong originates in Tibet), has not signed the 1995 agreement. She has ambitious hydroelectric plans that may influence conditions downstream adversely (Dupont, 1998, p. 72).

The cooperation scenario also points to more realistic pricing as a way of regulating the use of water. Traditionally, water has been perceived as a public good, to be consumed or polluted at will. As Falkenmark and Lundqvist (1998, p. 37) argue, “ . . . most people tend to take water for granted”. Increasingly, the use of water comes under public and private regulation, which permits realistic pricing. As Beaumont (1997, p. 361) points out, in restaurants people are willing to pay up to US$1000 per m^3 for brand-named bottled waters that are not very different in quality from the water obtained from the public supply. The cooperative scenario, then, argues that the same conflict-regulation processes as other scarce resources, including the judicious use of market mechanisms, may peacefully regulate conflict over water resources. Of course, human affairs are not always conducted wisely, so violent conflict could still occur.

The incentives for cooperation may depend on the nature of the water dispute. Wallensteen and Swain (1997, pp. 28–29) argue that in rivers where there is a *quality* problem, such as in the Rhine or the Colorado River, there is a strong incentive for cooperation among the riparian states. In the Nile and Ganges, characterized by a *quantity* problem, the incentives for cooperation are less obvious. In these cases, negotiations tend to be bilateral, and military threats and boycotts routinely become part of the bargaining behavior.

Previous studies

Apart from the studies of territory and war summarized earlier, there are very few large-*n* or even comparative studies of the relationship between resource competition and armed conflict. Tir and Diehl (1998) have summarized the literature on population pressure and interstate conflict, and have tested the relationship between conflict and population density and growth over the period 1930–89. They concluded that with appropriate control variables, population growth did appear to be moderately related to interstate conflict, but that population density had no effect. In neo-Malthusian thinking, involving environmental pessimism, population pressure plays a major role in increasing resource scarcity (Ehrlich & Ehrlich, 1972; Homer-Dixon, 1999). Cornucopian thinkers, on the other hand, who are more inclined to technological optimism, argue that population growth is outpaced by human innovation and therefore has little effect on resource scarcity (Lomborg, 1998, 2001).[7]

Summarizing a large number of case studies that he has carried out with various associates, Homer-Dixon concludes that “environmental scarcity has often spurred violence in the past” (1999, p. 177) and that “in coming decades the world will probably see a steady increase in the incidence of violent conflict caused, at least in part, by environmental scarcity” (1999, p. 4). However, he has also made it clear that at this stage he cannot identify any clear “causal effect”, and that his work is

[7] For a debate starkly contrasting the two views, see Myers & Simon (1994). A interpretative survey of the debate is found in Ohlsson (1998).

limited to establishing “causal mechanisms” (Schwarz, Deligiannis & Homer-Dixon, 2001).

In view of the many alarming public statements regarding water and conflict, there is surprisingly little relevant systematic research on this issue. Work by Falkenmark (1990), Gleick (1993a, 1993b), and others is valuable in clarifying the mechanisms by which conflict could occur, and by mapping the potential locations. However, these authors have not demonstrated that problems of water-sharing have actually played an important role in escalating conflicts to war.

Many authors have pointed to the Middle East as a particularly likely location for a ‘water war’. Water played an important role when Israel in March, May, and August 1965, as well as in July 1966, attacked the water diversion works of Syria, Jordan, and Lebanon with tanks and aircraft. This project, named the Headwater Diversion Plan, would have channeled the Hasbani River in Lebanon and Banias River in Syria, two of the sources of the Jordan River, around Lake Tiberias through Syria to the Yarmouk River where the water would have been regulated by a Jordanian dam at Mukheiba (Naff & Matson, 1984, p. 43). It has also been argued that these trends towards competitive utilization of the water in the Jordan River system played a key role in the Six-Day War in 1967. In that war Israel destroyed a Jordanian dam on the Yarmouk, the most important tributary to the Jordan River. Regardless of the role of the water, Israel, by conquering the West Bank and the Golan Heights from Syria, improved its hydrostrategic position through control of the Upper Jordan River. The occupation of the Golan Heights made it impossible for the Arab states to divert the Jordan headwaters. The 1969 ceasefire lines gave Israel control of half the length of the Yarmouk River, compared to 10 km before the war. During the summer of 1969 Israel also bombed the East Ghor Canal, today’s King Abdallah Canal, the most vulnerable target among Jordanian water facilities (Naff & Matson, 1984, p. 44). Although such conflicts over shared water resources appear to be zero-sum games, it seems far-fetched to argue that water is the main or even a very important general reason for war in the Middle East. After King Hussein gave up his claim to the West Bank in 1988, this dispute became detached from other strategic interests and could therefore be regarded as a genuine water conflict (Libiszewski, 1995, p. 36). Nevertheless, the basic issues of nationalism and control of land territory seem vastly more important factors in most of the disputes in the Middle East. Wolf (1999b, p. 254) says categorically that “the only problem with these theories is a complete lack of evidence” and that “water was neither a cause nor a goal of any Arab–Israeli warfare”.

The conflict scenario could be defended on the grounds that the future is likely to be different from the past. Gleditsch (1998, pp. 393–394) has criticized the widespread tendency in studies of environmental security to refer to future crises as empirical evidence. A convincing scenario that argues that the future is going to be different from the past requires a clear specification of theoretical mechanisms. Citing a 1979 statement by Anwar Sadat that “the only matter that could take Egypt to war again is water” (Gleick, 1993a, p. 86) is not equivalent to showing why and when such threats are likely to be carried out. However, Gleick (1993a, p. 79) does not rely only on the future: “History is replete with examples of competition and disputes over shared water resources", he argues. He goes on to say that he will "describe ways in which water resources have historically been the objective of interstate politics, including violent conflict". His examples of water-induced conflict, apart from the Six-Day War, are verbal conflicts between states, threats of violence, and water-related violence in ongoing wars, rather than a historical argument that conflicts over scarce water played an important role in the outbreak of the war. In a more recent publication, Gleick (1998, pp. 25–31) identifies in detail 54 historical and ongoing disputes and conflicts over freshwater resources. In most of these disputes, water is an instrument of war or a strategic target, rather than a scarce resource at the root of the dispute.

One of the few large-*n* studies of environmental conditions and conflict, Hauge & Ellingsen (1998), included an investigation of the relationship between freshwater availability and violent *domestic* conflict. Their model used two variables of environmental degradation (deforestation and land degradation) and five control variables (wealth, inequality, regime type, political instability, and population density), as well as a control for temporal dependence (conflict last year). They found that low freshwater availability per capita (0–500 m^3 per capita per year) was associated significantly with the incidence of civil war 1980–92 as well as domestic armed conflict more generally for the years 1989–92. Water scarcity was also associated with the number of civil war battle-deaths, in a model with a similar set of control variables plus military expenditure as a share of GDP. However, Hauge and Ellingsen did not study the possible international ramifications of competition over freshwater.

In this study, we make a first attempt to study systematically the effect of shared water resources, or more specifically shared rivers. There have been many case studies of shared rivers, but we are not aware of any previous large-*n* studies in this area.

Shared rivers

Based on the literature on water shortages, we expect countries with shared rivers to have more armed conflict and militarized disputes than other dyads. We could have formulated a hypothesis in terms of shared water resources generally, but we have data only on shared rivers. We do not necessarily expect the relationship between shared rivers and conflict to be very strong, or to dominate other factors of conflict. But even if the cooperative scenario is often correct, there should be some cases where foolish policies have prevailed and led to conflict. Thus our first hypothesis is:

H1: Everything else being equal, countries that share a river have more dyadic conflict behavior

Boundaries between two countries may vary from a few kilometers to several thousand. Thus, it is not surprising that dyads may share more than one river. We assume that an additional shared river increases the likelihood that some conflict issue will arise. Of course, having more shared rivers might also lead to more cooperation, if the cooperation scenario is correct. However, our hypotheses focus on the conflict aspect. Thus the next hypothesis:

H2: The more shared rivers between two countries, the higher the probability of conflict behavior between them

Water shortage is not the only mechanism by which rivers may generate conflict. Conflict may also be generated by the use of a river for navigation purposes. For instance, the use of the Mekong river for transportation through Vietnam into Phnom Penh led Cambodia to oppose a development aid-funded bridge project in Vietnam unless the bridge was high enough to accommodate the ships (Chou, 1998). Another potential source of conflict derives from the use of rivers for international boundaries. While in a sense they are obvious candidates for this role, rivers are somewhat devious boundaries because they do not stay in the same place. They erode the landscape, dig new outlets, etc. The legal boundary usually follows the *Thalweg* (i.e. the line following the deepest part of a river), but its location may change over time. An island that belongs to one country may eventually end up on the other side of this line. A dispute about the boundaries in the Ussuri river occasioned an armed confrontation between China and the Soviet Union in 1969. Finally, shared rivers may generate conflicts over pollution (Shmueli, 1999), although it is not generally suggested that by itself this is sufficient to lead to armed conflict.

Rivers may run along the border, as does the Congo, which separates the former French and Belgian colonies. They may also run from one country into another, as when the Nile crosses from Sudan into Egypt. We shall refer to the first type as a *river boundary* relationship, and to the second as an *upstream/downstream* relationship. Fig. 1 illustrates the two, plus a mixed type. The three types of conflict issues that we have mentioned impinge in slightly different ways on these two relationships:

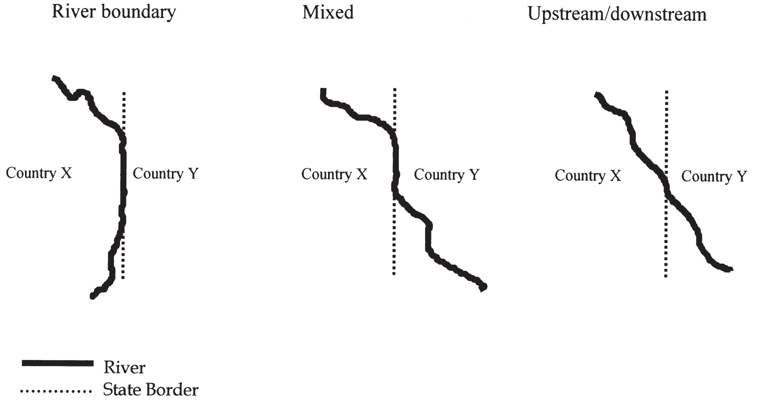

Fig. 1. Different forms of shared rivers in dyads. Each shared river is classified as one of three types: river boundary; mixed; upstream/downstream. A dyadic relationship may be classified as one of these three or as having several rivers with different types. In order to count as a river boundary type or a mixed type, the river has to run along the boundary of the dyad for more than 10 km.

sharing water resources can create problems in both types of relationships, but much more seriously in the upstream/downstream relationship. In a river boundary situation, the country on the left bank may divert water, but the country on the right bank has an obvious form of retaliation: to divert water to its own side of the river. *Navigation problems* and *transborder pollution* may occur in both cases, while *boundary problems* would occur only in the river boundary situation. It is not obvious how this adds up, but given the focus on water shortages in the literature, we expect the upstream/downstream relationship to have a higher conflict potential. We anticipate that the incentives for cooperation will be higher for countries sharing a river boundary than in an upstream/downstream situation characterized by zero-sum relations and lack of confidence. Our next hypothesis is therefore:

H3: Among countries with shared rivers, upstream/downstream situations have more dyadic conflict behavior

We also want to test a common assumption in the neo-Malthusian literature, that resource and environmental issues are becoming more important conflict factors. We therefore formulate a hypothesis to the effect that to the extent there is a resource scarcity problem linked to shared water resources, it has probably become more serious over time, because of population growth and increasing consumption. Moreover, we would expect water issues to emerge as more important as a factor in global conflict after the end of the Cold War, when the world is no longer locked into a tightly bipolar confrontation between East and West reinforced by mutual nuclear deterrence.

Our fourth hypothesis is:

H4: The relationship between shared river boundaries and conflict is accentuated over time

Finally, we want to test more directly a hypothesis about water sharing, the main mechanism in the presumed causal chain from shared rivers to conflict behavior. We follow the dominant view of water conflict in positing that water scarcity might be related to conflict:

H5: Everything else being equal, two contiguous countries with water scarcity are more likely to have conflict behavior

Finally, we will investigate the interaction between water scarcity and river borders:

H6: Water scarcity increases the extent to which river-sharing is associated with dyadic conflict behavior

Other factors

The phrase ‘everything else being equal’ implies a series of hypotheses about interstate conflict. Multivariate studies such as Bremer (1992), Oneal & Russett (1999), and Hegre (2000) indicate which factors increase the probability of interstate conflict behavior between two countries A and B: one or both are major powers, the two are about equally powerful, neither country is a democracy, the two are not allied to one another, they have a history of violence, neither country is rich, they trade little with one another,[8] and A is already at war with a third country C which is contiguous or allied with B. In this study, we control for regime type, economic development, major power, peace history, and alliances. In addition, contiguity is a selection factor here: our analyses are for contiguous countries only.

For some of these controls, a multivariate framework is essential. For instance, allied countries and rich countries tend to cluster geographically and allied dyads therefore appear to fight each other more frequently if one does not control for contiguity.

We study the years 1880–1992, a period for which data are widely available for all control variables, but also report results for a shorter time period.

Data

Shared rivers

The data on shared rivers are taken from Toset (1998). He, in turn, started from the contiguity dataset of the Correlates of War (COW) Project (Gochman, 1991). This dataset distinguishes between land contiguity through the main territory of the states, land contiguity through dependent territory, and contiguity by sea in three categories if the countries are separated by less than 150 miles of water. The latter form of contiguity is less relevant here, since by definition two countries cannot share a river if they are separated by sea. We exclude contiguity of dependent territories, since we assume that most of the conflict-generating effect of having dependencies is picked up by the great power variable.

In order to identify shared rivers, Toset (1998) relied heavily on a UN register (CNRET, 1978) which claims to include all rivers 10 km long or longer for all the world except Asia. The culmination of a 20-year effort by a now defunct UN body, its final report listed 214 major shared international freshwater resources, 148 of which flow through two countries only, and the rest through three or more.[9] The

[8] The relationship between trade and conflict remains somewhat contested; see Oneal & Russett (1999), Beck, Katz & Tucker (1998) Barbieri & Schneider (1999).

[9] For a brief description of the CNRET reports, see Swain (1997, p. 404). A recent World Bank report refers to “over 245 river basins”, which serve about 40% of the world’s population and half its area (Salman & Boisson de Chazournes, 1998, p. vii). Wolf et al. (1999) have updated the UN register to list 261 international rivers, which cover almost half the land surface of the globe. Milich and Varady (1999, p. 259) put the number of shared river basins at “more than 300”.

number 214 is cited frequently even though it was never completely accurate and has become less so with the further proliferation of new states.[10] Toset supplemented the CNRET data with more detailed information for Asia and for historical boundaries from sources such as Granzow (1898), Westermanns Atlas zur Weltgeschichte (1956), and The Times Atlas (1997). The maps varied in scale and reliability and the coding was bound to involve some inaccuracy, particularly for the older dyads. An example of a particularly complex and difficult area is the desert and swamp territory between Iraq and Syria. Biswas (1990) has criticized CNRET for not consulting other projects and for not making use of the best maps. Its definition of river basin also excludes a number of international river systems from its register. For instance, CNRET recognizes only one river basin in the India–Bangladesh area, Ganges–Brahmaputra (shared by India, Bangladesh, China (Tibet), Nepal, and Bhutan), while the Indo-Bangladesh Joint River Commission identified 54 river systems divided between those countries (Swain, 1996, p. 161). Nevertheless, the CNRET register provided the best starting point for a systematic empirical study.

Coded in dichotomous form, Toset's dataset contains a total of 1274 dyads with shared rivers over the 1816–1992 period, and 13,707 dyad-years with shared rivers.[11] About 80% of the contiguous dyads share rivers. Of these, in turn about 8% are coded as having a very high number of shared rivers (10 or more). The approximately 8000 river boundary dyad-years coded on the basis of CNRET (1978) were coded as having a short, medium, or long river boundary. A total of 30% were in the 'short' category (less than 100 km) and 26% were 'long'. Of the shared river dyad-years, 8% had river boundaries, while 30% were simple upstream/downstream types. Also, 13% of the shared river dyad-years had multiple border crossings and no less than 48% had more than one type.

Toset's dataset also includes the total area of the river basin, each state's share of the river basin, and which of the riparian states is upstream. These additional variables have not been used in the analysis. The upstream/downstream variable is potentially the most interesting one. Since an upstream country can restrict the supply of water, we might expect downstream countries to be more likely to initiate conflict behavior against upstream countries. However, the downstream country can restrict navigation for upstream countries, leading to precisely the opposite prediction. We do not have data on the kind of restrictions that upstream countries may have imposed on their downstream brethren or vice versa. In any case, we do not think that the COW data on the initiation of conflict behavior are reliable enough to justify such an analysis.[12]

A weakness of the Contiguity dataset is that it does not have clear criteria for how to deal with territory occupied by another state. An example is the border area

[10] In particular, the fragmentation of the Soviet Union. Russia and the Ukraine (since 1991) have more shared rivers than any other dyad. Part of this increase in internationally shared rivers was offset by the reunification of Germany and the Yemen after the end of the Cold War.

[11] A dyad is a pair of states. In the dataset, information is recorded for each 'dyad-year', i.e. for each dyad for every year in the period.

[12] This problem is discussed in Gleditsch & Hegre (1997, pp. 294–297).

around the Golan Heights between Israel and Syria, occupied by Israel since 1967. In generating river boundaries in this area, Toset used the original borders if the occupation was not recognized by the states involved.

Conflict behavior

The source of the main dependent variable is the Militarized Interstate Disputes (MIDs) dataset from the Correlates of War project (Gochman & Maoz, 1984; Singer & Small, 1994). The interstate war variable of the COW project has one general weakness from an analysis point of view: because there are few of them, the results may be overly dependent on a few historical events, particularly in analyses of shorter time periods. A specific weakness of using interstate wars for this particular analysis is that it may be unreasonable to expect disputes over water to escalate all the way to war. Some of the more dramatic predictions, of course, foresee that the escalation will go that far. But it seems more reasonable to hypothesize that many of the conflicts will de-escalate before they cross a threshold of 1000 battle-deaths in a single year. The MIDs—which include a range of low-level hostilities including threats to use force and displays of force—are much more numerous, but are widely assumed to be somewhat less reliably coded and with greater uncertainty than the wars about the start and end dates. They also suffer from what might be called an ‘attention bias’: while a war can scarcely be hidden from public view, a militarized dispute may not catch the attention of the media and thus will not have been caught by the COW coders. The harm done by the least serious MIDs (threat of force) is also frequently quite marginal and the practical significance of a relationship between shared rivers and such conflict behavior can be questioned. We choose an intermediate solution here and measure conflict behavior as the onset of a MID with at least one casualty. This should reduce attention bias considerably.

Control variables

We measure *major power* with the standard dichotomous variable from the COW project (Small & Singer, 1982) and score the dyad-years as involving 0, 1, or 2 major powers. *Regime type* is measured by Polity III (Jaggers & Gurr, 1995). Countries with 3 or higher on the difference between institutionalized democracy and institutionalized autocracy were characterized as democratic, and the dyad-years were coded as involving 0, 1, or 2 democracies. Dyads in which at least one country were in regime transition or missing data for other reasons were coded as a separate category labeled Regime transition/NA. *Economic development* was coded by using the log of energy consumption per capita from the National Material Capabilities Dataset of the Correlates of War Project (Singer & Small, 1993, and additional data coded from UN sources taken from Gissinger & Gleditsch, 1999). Energy consumption and GDP per capita each have their problems as measures of economic development; decisive for our choice was the fact that the former variable is available for a much longer time-span. We assume that the least developed country in the dyad is the one least constrained of the two against the use of force.[13] Consequently, we use the lower log of energy consumption per capita in the dyad as the dyadic form of the development variable. Another variable from the COW project is *alliances* (Singer & Small, 1993, p. 5). The COW project lists three types of alliances: defense pacts, neutrality pacts, and ententes. We excluded the neutrality pacts and merged the other two categories as our indicator of shared alliance (cf. Raknerud & Hegre, 1997, p. 398). An alliance concluded in one year is coded as in effect from the next year. An alliance ended in a particular year is coded as a non-alliance from that same year. An alliance formed and ended in the same year is not coded at all. To control for temporal dependence between units of analysis, we added the variable *Peace history* to the model. The variable was defined as $-\exp\{(-\text{years in peace})/\alpha\}$ where 4.329 was chosen as a value for α. 'Years in peace' is either the number of years since the two states were on opposite sides of a militarized dispute or since the youngest state gained independence.[14] The function models the log odds of a militarized dispute in the dyad as high just after a previous dispute/independence then decreasing at a constant rate. The variable ranges from -1 to 0. For this value for α, the impact of Peace history on the log odds of conflict has a half-life of exactly 3 years.[15] Finally, *freshwater availability* was taken from a dataset generated by Hauge and Ellingsen (1998). They coded low, medium, and high availability on the basis of data from *World Resources* (WRI, 1986–95). We have used 10,000 m^3 per capita per year as the cutoff point for a dichotomous measure of freshwater availability, and have coded dyad-years as having 0, 1, or 2 countries with low availability. This variable includes water from rivers as well as ground water. Water in rivers with their sources from outside the border is excluded for all countries, except Africa and South America. This variable was only used for analyzing data from the most recent period. Even so, it is problematic that it is only available for a single year. The variable is also insensitive to seasonal variations in rainfall and to national differences in the use of water.[16] However, given the importance of water scarcity to theories of water conflict, we do need to include such a variable.

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[13] See Dixon (1994) on this 'weak-link assumption' in the context of testing the democratic peace.

[14] See Raknerud & Hegre (1997) for a discussion of the problems with temporal dependence in a similar context. The value 4.1 for α is the value that maximizes the log likelihood in Model 1 (log likelihood=-1043.27). We chose the value 4.329 since this corresponds to an integer half-life (3 years) with insignificant loss of goodness-of-fit.

[15] We also estimated all models using the 'cubic splines' correction for temporal dependence proposed by Beck et al. (1998). This method applies a smoothing function to the variable counting years of continuous peace in the dyad before the year of observation and the probability of conflict instead of the decaying function used above. We used S-Plus to estimate this model. However, this estimation yielded a lower log likelihood value than the estimations reported above (-1053.98 as compared to -1043.30). Since it is both more parsimonious and fits the data better, we prefer the decaying-function correction. The choice between the two has only minor consequences for the other estimates of the model.

[16] We are grateful to Phil Steinberg for this point.

Results

Table 1 reports results from the estimation of bivariate logistic regressions for the shared river and water availability variables as well as for the control variables. We report the parameter estimates, but have also calculated the odds ratios and the relative risks of conflict. The *odds ratio* is the ratio of the estimated odds of conflict for one group to a reference group, where the odds is the probability of conflict in the group divided by the probability of no conflict:

$$\text{odds ratio}=\frac{p(\text{war})_1/p(\text{not war})_1}{p(\text{war})_0/p(\text{not war})_0}$$

where the subscripts refer to the two groups we compare. For the dichotomous variables, group '0' refers to the dyad without the relevant characteristic. The *relative risk* is the probability of conflict when a risk factor was present divided by the probability of conflict when it is not present:

Table 1
Bivariate analyses of outbreak of militarized interstate disputes, all contiguous dyads, 1880–1992

Variable	Parameter estimate	Standard error	Odds ratio	Relative risk[a]	*N*
Shared river vs. no shared river	1.3***	0.23	3.7	3.2	13,899
One democracy vs. two democracies	0.79***	0.21	2.2	2.1	13,899
Zero democracies vs. two democracies	0.28*	0.21	1.3	1.3	13,899
Transition/missing regime data vs. two democracies	0.64***	0.26	1.9	1.8	13,899
One or two major powers vs. no major powers	−0.49***	0.17	0.61	0.63	13,899
Energy consumption per capita	−0.11***	0.033	0.90[b]	0.90	11,665
Shared alliance vs. no alliance	−0.59***	0.13	0.55	0.57	13,899
Peace history	−3.6***	0.19	36.6[c]	13.2	13,899
Two countries with low water availability vs. zero countries with water scarcity[d]	1.6***	0.60	4.8	4.0	3069
One country with low water availability vs. zero countries with water scarcity[d]	1.5***	0.63	4.4	3.8	3069

* $p<0.10$; ** $p<0.05$; *** $p<0.01$. All *p*-values refer to one-sided tests.

[a] The relative risk is calculated assuming the baseline probability of dispute is 0.05. If the baseline probability is lower, the relative risk is closer to the corresponding odds ratio.

[b] For Energy consumption per capita the odds ratio refers to the difference between a dyad with lower energy consumption which is e=2.7 times larger than another dyad (i.e. the odds ratio for dyads with one unit's difference on the ln(energy consumption per capita).

[c] For Peace history the odds ratio refers to the difference between a dyad with several decades of peaceful existence with one with a peace history close to zero years.

[d] The figures for water availability were available for the 1980–92 period only.

$$\text{relative risk}=\frac{p(\text{war})_1}{p(\text{war})_0}$$

Since the probability of war is dependent on other variables in the model, we assume that $p(\text{war})_0$=0.05.

The relationship between odds ratio and relative risk depends on the two probabilities of conflict (see Agresti, 1990, p. 17):

$$\text{odds ratio}=\text{relative risk}\left(\frac{1-p(\text{war})_1}{1-p(\text{war})_0}\right)$$

When the baseline probabilities are very low and the odds ratio moderate, the relative risk is roughly equal to the odds ratio, as can be seen from Table 1.

The bivariate analyses show preliminary support for Hypotheses 1 and 5: countries that share a river have more dyadic conflict behavior, and dyads where one or two countries have low water availability also have more dyadic conflict behavior. For the control variables, the results are generally in line with previous studies. One exception is the major power variable. Most studies (e.g. Bremer, 1992; Raknerud & Hegre, 1997) find major powers to be more often engaged in militarized conflicts than minor powers, whereas we find that dyads including one or two major powers have less conflict. This discrepancy may reflect that we study only contiguous dyads, where the major powers' ability to wage war over long distances is less relevant. At the same time, most of the dyads containing major powers consist of only one of these. In such dyads, the major power is much more powerful than the other state. Many studies have found power preponderance in a dyad to reduce the probability of war (e.g. Oneal & Russett, 1999).

All these computations are for contiguous dyads only. At the bivariate level, the impact of Contiguity is an order of magnitude higher than the impact (in the contiguous dyads) of Shared river or any of the other variables in Table 1. Bremer (1992) finds contiguous dyads to be more than five times as likely between contiguous dyads than between non-contiguous dyads. Raknerud and Hegre (1997, p. 394; footnote 14) estimated a contiguous dyad to be from 13 to 40 times more war-prone than a non-contiguous dyad (the estimated relative risk varies with the number of states in the international system).

In Table 2, we test Hypotheses 1 and 2 in two multivariate models. Model 1 investigates the relationship between the dichotomous indicator 'Shared river' or not and militarized disputes with at least one casualty.[17] Model 2 studies the relationship between 'Number of shared rivers' and dispute. All the control variables listed above except water availability have been included in the models.

Compared to the bivariate results, the parameter estimate for 'Shared rivers'

[17] We have also tested Model 1 using all MIDs and all MIDs with at least 25 casualties. The 'Shared river' variable was significant also using these dependent variables, although less significant than for the MID-with-one-casualty variable. This is not surprising given that the full set of MIDs contains much more noise (e.g. attention bias and non-systematic errors) and the set of MIDs with 25 casualties contains fewer conflict onsets.

Table 2
Logistic regression for the outbreak of interstate militarized disputes, all contiguous dyads, 1880–1992

Variable	Model 1 Parameter estimate	Model 1 Standard error estimate	Model 2 Parameter estimate	Model 2 Standard error estimate
Constant	−5.3***	0.31	−4.8***	0.23
Shared river				
No	ref.			
Yes	0.87***	0.24		
Number of shared rivers			0.063***	0.016
Regime type				
Two democracies	ref.		ref.	
One democracy	0.10	0.23	0.11	0.24
Zero democracies	−0.07	0.24	−0.14	0.30
Regime transition/NA	−0.070	0.30	−0.050	0.19
Major powers in dyad				
None	ref.		ref.	
One or two	−0.62***	0.19	−0.74***	0.18
Economic development	−0.054*	0.042	−0.064*	0.042
Alliance				
No	ref.		ref.	
Yes	−0.43***	0.15	−0.47***	0.15
Peace history	−3.5***	0.21	−3.5***	0.21
Number of dyad-years	11,476		11,476	
Log likelihood	−1043.30		−1044.33	

* $p<0.10$; ** $p<0.05$; *** $p<0.001$. All *p*-values refer to one-sided tests.
'ref.' signifies that this category is the reference category for the categorical variable.

(Model 1) is slightly smaller—corresponding to an odds ratio of 2.4. However, the relationship is still highly significant, both statistically and substantially. Dyads that share a river are 2.4 times more likely to be involved in militarized disputes than other contiguous dyads.[18] The estimated effect of this variable is stronger than any of the control variables.

In the multivariate model, the regime type variables are all insignificant. This may be due to the inclusion of an economic development variable (cf. Hegre, 2000). According to the estimates in Model 1, a dyad with 1.16 as the lower log of energy consumption per capita (corresponding to Austria in 1985) is 23% less likely to be involved in a militarized conflict than one with lower log of energy consumption per capita of −3.76 (Mali in 1986).[19] As in the bivariate analyses, we find the existence of major powers in the dyad and shared alliances to roughly halve the risk of conflict.

[18] Throughout, we use 'more likely' as a generic term. Here, it refers to the odds ratio. For the baseline probability in this dataset the odds ratio is roughly equal to the relative risk.

[19] The dyadic development variable ranges from −9 (Afghanistan in the 1920s) to nearly 3 (Qatar and the United Arab Emirates in the early 1980s), with 80% of the observations between −3.76 and 1.16.

Hypothesis 2 is tested in Model 2 in Table 1. The positive parameter estimate for 'Number of shared rivers' is consistent with the hypothesis: the more rivers two countries share, the higher the likelihood of conflict. However, the more refined measure does not add much explanatory power over the simple dichotomous 'Shared river': the parameter estimate is small, and the log likelihood for Model 2 is lower than that for Model 1.

An analysis for a shorter and more recent period (1980–92) is reported in Table 3, Model 3. This analysis gives very similar results. The parameter estimate is identical to the longer period. The estimate for the standard error is larger as expected when reducing the number of observations from 11,476 to 2747, such that the statistical significance of the variable is considerably lower in Model 3 than in Model 1.

Hypothesis 3 is tested in Model 4. 'Upstream/downstream' is estimated to be the most conflict-prone type of shared river, 'Mixed Boundary' is the second most con-

Table 3
Logistic regression for the outbreak of interstate militarized disputes, all contiguous dyads, 1980–92

	Model 3		Model 4	
Variable	Parameter estimate	Standard error estimate	Parameter estimate	Standard error estimate
Constant	−6.1***	0.77	−6.1***	0.77
Shared river				
No	ref.			
Yes	0.87**	0.48		
Type of shared river				
None			ref.	
River boundary only			0.82*	0.54
Mixed boundary			1.02**	0.59
Upstream/downstream			1.24**	0.60
Several categories			0.74	0.53
Regime type				
Two democracies	ref.		ref.	
One democracy	0.57	0.60	0.52	0.60
Zero democracies	0.34	0.59	0.27	0.60
Regime transition/NA	−0.93	1.2	−0.99	1.2
Major powers in dyad				
None	ref.		ref.	
One or two	−0.27	0.48	−0.28	0.49
Economic development	−0.13*	0.097	−0.12	0.098
Alliance				
No	ref.		ref.	
Yes	−0.34	0.31	−0.27	0.33
Peace history	−3.5***	0.46	−3.6***	0.47
Number of dyad-years	2747		2747	
Log likelihood	−225.48		−224.75	

* $p<0.10$; ** $p<0.05$; *** $p<0.01$. All *p*-values refer to one-sided tests.
'ref.' signifies that this category is the reference category for the categorical variable.

flict-prone, and ‘River boundary only’ the third. This is in line with the hypothesis. However, the differences between the types are not statistically significant.

Hypothesis 4 suggested that shared rivers should be more likely to lead to conflict in the later period than in the shorter period. This can be tested by comparing the results in Table 3 with those in Table 2. The parameter estimate is the same for both periods, so we have no basis for concluding that the effect of shared rivers is increasing over time.[20]

The control variables are less significant in Models 3 and 4 than in the first two models. Economic development remains weakly significant in Model 3, but becomes insignificant in Model 4.

Hypotheses 5 and 6 are tested in Table 4. Hypothesis 5 receives clear support in Model 5: dyads where at least one of the states has low freshwater availability are considerably more likely to get into serious militarized conflicts than states with ample supply of water. Dyads with water scarcity are estimated to have approximately four times higher risk of conflict than dyads without.[21]

In model 6, we have added an interaction term between ‘Shared rivers’ and ‘Low water availability’ to test Hypothesis 6. The positive and significant estimate for the interaction term may indicate that low water availability increases the risk of militarized conflicts over rivers. The improvement in log likelihood from Model 5 is 1.48. The likelihood ratio test *p*-value is 0.085, implying that the interaction term somewhat improves the goodness-of-fit of the model. However, the estimation suffers from serious problems of collinearity, warning us not to draw to firm conclusions from these results.

Discussion

Our empirical results provide some support for the idea that shared river dyads have a higher frequency of dispute outbreaks than other contiguous dyads. Although the effect of a shared river is much lower than that of contiguity itself, it is of the same order of magnitude as the standard variables used to account for interstate conflict, such as regime type, economic development, great power status, and alliances. Clearly the analysis can be refined in various ways—for instance by developing better measures of different types of shared rivers, by distinguishing between major and minor rivers, and by including a more complete set of control variables.

One potentially important factor that we have not controlled for is the length of the border separating the two states in the dyad. The longer the border, the more

[20] As alternative tests of Hypothesis 4, we tried adding indicator variables for various periods and adding a linear time variable to Model 1. This led to severe problems of collinearity and showed no signs of support for the hypothesis.

[21] We also estimated models where we distinguished between one state with low water availability and two states with low water availability. We found no difference between these two categories, nor did the division lead to a better goodness-of-fit.

Table 4
Logistic regression for the outbreak of interstate militarized disputes, all contiguous dyads, 1980–92

	Model 5		Model 6	
Variable	Parameter estimate	Standard error estimate	Parameter estimate	Standard error estimate
Constant	−7.5***	0.98	−5.4***	1.2
Shared river				
No	ref.		ref.	
Yes	0.98**	0.49	−1.5	1.3
Water availability				
Neither state low	ref.		ref.	
One or both states low	1.5***	0.62	−0.80	1.1
Shared river and water availability				
Shared river and one or two states with low water availability			2.7**	1.4
Other combinations			refs.	
Regime type				
Two democracies	ref.		ref.	
One democracy	0.58	0.61	0.59	0.61
Zero democracies	0.18	0.59	0.20	0.59
Regime transition/NA	−0.99	1.2	−0.95	1.2
Major powers in dyad				
None	ref.		ref.	
One or two	−0.26	0.48	−0.26	0.48
Economic development	−0.11	0.094	−0.11	0.094
Alliance				
No	ref.		ref.	
Yes	−0.16	0.33	−0.13	0.32
Peace history	−3.5***	0.46	−3.5***	0.46
Number of dyad-years	2747		2747	
Log likelihood	−220.73		−219.24	

* $p<0.10$; ** $p<0.05$; *** $p<0.01$. All p-values refer to one-sided tests.
'ref.' signifies that this category is the reference category for the categorical variable.

opportunities for conflict and potential contentious issues for conflicts. At the same time, it is more likely that states with a long shared border share a river than states with a short shared border. There is therefore a danger that the shared river variable might act as a proxy for border length. However, the 'Number of rivers' variable should then be even more highly correlated with the length of the shared border. If the relationship between shared rivers and conflicts was indeed spurious, we would expect this variable to be even more closely related to conflict than the 'Shared river' variable. This is not the case.

Of course, a border crossed by several rivers might have greater permeability than a border through a desert or over inhospitable mountains. The permeability would permit interaction, which in turn could generate conflict. Borders without rivers are also likely to be found in sparsely populated regions where there is a smaller chance that frictions develop. It would be useful if future studies of the relationship between shared rivers and conflict could include the length of the border as a control variable.

We asked at the outset what it is about territory that makes it worth fighting for. Our tentative conclusion is that there is something to shared rivers as a source of conflict. Whether this ‘something’ is mainly water scarcity is not clear. The results indicate that low availability of water in both countries in the dyad is significantly related to disputes. However, the results for the type of shared river variable indicate that it is not only water scarcity and the potential for serious upstream/downstream conflict that threatens the peace in shared river dyads. For the river boundary dyads in particular, it may rather be a question of friction over navigation, pollution, fishing rights, or territorial issues. Better data for the type of shared river might put us in a position to answer such questions more precisely.

We have no data on the actual issues involved in the COW disputes in the shared river dyads and in other dyads. The MID dataset includes a dispute-type variable which allows distinguishing between territorial conflicts and other conflicts, but not between different types of territorial conflict. More directly relevant, the Issues Correlates of War project[22] is collecting new data on freshwater claims, but the fruits of this work will not be available for some time. Conceivably, the shared river dyads might be feuding over entirely different issues. If we had data which showed that to be the case, we would need to look for a third variable which would account for the statistical relationship between shared rivers and disputes. If no such variable could be found, we should still suspect that the shared rivers in many cases were at the root of the problem and that the other issues were mostly rhetorical. On the other hand, if it could be demonstrated by issue coding of the disputes that shared river dyads do indeed feud over their joint water resources, the case for considering shared rivers as a causal factor in conflict would be strengthened.

Wolf (1999b) has studied crisis behavior on the basis of the International Crisis Behavior dataset (Brecher & Wilkenfeld, 1997). The ICB project identified 412 crises for the period 1918–94. Through a search of the text files for the dataset, Wolf found four disputes where “water was at least partially a cause”. His own research added three more cases.[23] In three out of these seven crises, not a single shot was fired. None of the others were violent enough to qualify as wars. Wolf (1999b, p. 263) argues that the last and only water war was the conflict between the Sumerian city states of Lagash and Umma, which occurred 4500 years ago. However, the lack of clean freshwater may lead to political instability and acute small-scale violence, as shown by Hauge and Ellingsen (1998).

Wolf feels that the history of water dispute resolution is much more impressive. He cites studies from FAO (1978, 1984) which have identified more than 3600 treat-

[22] See Hensel (1998) and the project homepage at www.icow.org.

[23] The freshwater dispute database is described in Wolf (1999a). Data from this project are available on http://terra.geo.orst.edu/users/tfdd/.

ies relating to international water resources between 805 and 1984, most of which concern aspects of navigation. Since 1814, around 300 treaties have been concluded about non-navigational issues relating to international water resources. The UN General Assembly in 1997 passed an international convention on the non-navigational uses of international waterways (McCaffrey, 1998). And The World Bank and other international agencies are actively promoting the development of water regimes and joint exploitation of international rivers (Krishna, 1998).

We conclude, then, that the sharing of international rivers does seem to be associated with conflict between nations, as well as with activities directed at conflict prevention. At this stage we do not have much solid evidence for saying that sharing a river provides a major source of armed conflict, or that water scarcity is the only or even the main issue in whatever such conflicts do occur.

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