Relative Water Scarcity and International Behavior on Cross-Boundary Rivers:

Evidence from the Aral Sea Basin

How do countries that share cross-border rivers respond to periods of abnormally low water availability? Existing research on the effects of water scarcity focuses on the influence of cross-basin differences in absolute availability. This article argues that understanding whether countries react cooperatively or conflictually to within-basin shortages is equally important. To study the effects of within-basin, *relative* scarcity, the article uses the case of two major cross-boundary rivers in the Aral Sea basin of Central Asia. Employing original data on interactions among these countries over the issue of water management, the statistical analysis demonstrates that relative scarcity is associated with an increased likelihood of both cooperative and conflictual interactions. These findings suggest that country behavior changes in response to short-term shortages, underscoring the need to consider how relative water scarcity affects interstate relations among river-sharing countries.

1 Introduction

Securing access to international sources of fresh water, such as cross-boundary rivers, is a central concern for many countries. Each of the 276 international rivers in the world represents an unavoidable point of contact between countries and, consequently, has the potential for causing tension.[1] This potential increases dramatically if water is in short supply, making countries more likely to engage with one another in either a positive or negative manner. On the one hand, since water resources are limited, obtaining them is vital to country survival and therefore warrants the use of conflict-generating behavior. On the other hand, the costs associated with conflict are prohibitive even if water is scarce, and may induce countries to take a more cooperative approach.

[1]The number of international rivers comes from Wolf (2007: 242).

Existing research focuses on an *absolute* conceptualization of water scarcity, examining the effects of cross-basin variation in factors like water-flow levels. Such measures capture the nominal level of water in a given country, dyad, or basin unit. Using these measures, studies have found evidence of both cooperative and conflictual responses to scarcity.

The focus on cross-national variation in absolute levels of availability, however, obscures an important part of the water scarcity story by downplaying the role of scarcity *relative to* normal within-basin levels of availability. This kind of scarcity is equally important for determining country behavior, since obtaining access to water becomes increasingly vital during times of unusual shortage. These periods arise unexpectedly and typically do not last long enough for long-term, unilateral solutions, such as planting less water intensive crops or undertaking large infrastructure projects, to be effective. Consequently, countries are more likely to turn outward and engage with their neighbors in some fashion when relative scarcity is high.

This article refocuses attention on the importance of relative water scarcity by demonstrating that shortages of this kind have a real and important impact on country behavior. Specifically, I present evidence of how relative scarcity affects country relations within the Aral Sea basin of Central Asia. Using original data on cooperative and conflictual interactions among the five countries located within this basin, I find that periods of relative scarcity are positively related to an increase in the likelihood of both cooperative and conflictual interactions. In other words, short-term water scarcity leads these countries to interact with their neighbors, although the nature of this interaction takes very different forms.

The Central Asian case is valuable for studying within-basin variation in water scarcity for several reasons. First, focusing on the Aral Sea basin controls for structural and hydrological factors that might affect cooperation, while still allowing for comparisons between the two rivers in the basin. The shared experiences of the countries themselves under the Soviet Union and their fairly similar trajectories since independence also controls for country-level political and cultural factors that may affect their propensity for cooperative or conflictual interactions. Finally, these countries have developed a unique system of water management that involves frequent renegotiations of formal water agreements, making both cooperative and conflictual interactions more visible than they are in other instances of international water management.

Understanding the impact of water scarcity in Central Asia is also important in its own right. The resource management regime devised by the Soviets led to the rapid depletion of the Aral Sea and the environmental degradation of the surrounding region. The independent Central Asian countries must deal with this legacy; while full restoration is improbable, the possibility of mitigation remains (Micklin, 2007: 62-67). In addition, as a 2007 Human Development Report notes, Central Asia is particularly vulnerable to climate change and related changes in water flow patterns (United Nations Development Programme, 2007/2008: 18). More broadly, resource management has a serious impact on the economic development of the region (United Nations Development Project, 2005: 84-111). Given these challenges, the need to understand how relative scarcity relates to cooperation and conflict in this region has never been more pressing.

Correcting the existing bias towards an absolute conceptualization of water scarcity is particularly important in the face of climate change. Studies suggest there will be a sharp increase in the variability of water flows in many parts of the world.[2] If these predictions are correct, basins will experience increasingly large swings in the water available for consumption. Understanding how countries respond to extreme events of this kind will help policymakers develop long-term strategies for the management of international water resources.

Although the substantive findings are specific to the Aral Sea case, they have much broader implications for how we conceptualize water scarcity. By demonstrating that relative scarcity influences country behavior in important ways, the article highlights the fact that focusing on absolute scarcity cannot fully explain the relationship between water shortages and country behavior. Since there is no reason to suppose the countries of the Aral Sea basin are uniquely responsive to fluctuations in water availability, this is very likely to be true elsewhere in the world. Consequently, the effects of relative scarcity should not be ignored when considering how water availability influences country behavior.

2 Theory

In this section, I discuss the difference between absolute and relative conceptualizations of scarcity. Although absolute scarcity plays an important role in determining country behavior, I argue there are compelling reasons to expect that relative scarcity also affects how countries interact with one another over water issues. I then draw on existing literature to generate testable hypotheses about the effect of relative scarcity on country behavior.

2.1 The case for studying relative water scarcity

There are two ways to conceptualize water scarcity: the absolute quantity of available water and the amount relative to a basin-specific baseline. To illustrate the first of these, consider two frequently used measures: water discharge, which is the volume of water that passes through rivers in the basin; and water runoff, which is the amount of water flowing over land in that basin. These measures both capture how much water is available in a given basin. Some basins will, naturally, have much lower water discharge and runoff than others. For example, the Tigris-Euphrates/ Shatt al Arab basin, which contains parts of Iran, Iraq, Jordan, Saudi Arabia, Turkey and Syria, has an average runoff of 52,718 mm/year and a discharge of 11,200 cubic km/year. In contrast, the Mississippi basin, which includes parts of Canada and the

[2]See Adler (2008: 732-738) for an overview of the scientific literature linking climate change and water scarcity/variability.

USA, has an average runoff of 252,264 mm/year and an average discharge of 801,010 cubic km/year.[3] Absolute measures of this kind highlight the fact that there is simply more water in the Mississippi basin than there is in the Tigris-Euphrates/ Shatt al Arab basin. Even in a year of severe drought, the Mississipi basin has a higher discharge and runoff than the Tigris-Euphrates/ Shatt al Arab basin has in a year of supreme abundance.

Existing work on the relationship between water scarcity and international behavior focuses on absolute conceptualizations like those described above.[4] By using cross-basin measures, like water runoff or water discharge, these studies test the hypothesis that countries in certain basins act differently than others because these basins generally contain less water. In this article, I argue that countries also act differently when they have less water than usual. In other words, while comparing absolute scarcity *between* basins is important for understanding country behavior, so is comparing relative scarcity *within* basins. There are both theoretical and methodological reasons to believe this is the case.

First, relative water scarcity is particularly likely to spur countries to engage with their neighbors because other options tend to be limited. All else equal, countries might prefer unilateral solutions to water shortages that circumvent the need for trust at the international level and do not require countries to cede sovereignty over the issue of water management.[5] However, these are not feasible responses to relative scarcity, which comes on quickly and may last only a season or so. Unilateral solutions to water shortages take time to develop and implement. For example, the construction of desalination plants alleviates the costs of low water availability in the long-term, but a construction project of this size is not feasible as a direct response to short-term shortages; any benefits are unlikely to be felt before the period of scarcity ends. A similar argument can be made for investment in infrastructure that increases the efficiency of water use in agriculture or other areas. Even financially modest solutions, like encouraging the judicious selection of crops with low water requirements, may face delays due to farmer reluctance. The range of unilateral solutions to short-term scarcity is therefore limited. Faced with few other options, the likelihood that countries engage with their neighbors increases during such times.

Measures of absolute scarcity face an additional problem: they implicitly assume that a given level of availability means the same thing in all basins. In reality, this is not the case. As mentioned above, some countries use water more efficiently than others. Consider the example of irrigation. The water requirement ratio measures the amount of water needed to irrigate the

[3]These data are from the Transboundary Freshwater Spatial Database, Department of Geosciences, Oregon State University.

[4]For example, Hensel, Mitchell and Sowers (2006); Wolf, Stahl and Macomber (2003); Tir and Stinnett (2012); Tir and Ackerman (2009); Zawahri and Mitchell (2011); Brochmann and Hensel (2009; 2011) all use absolute measures as their primary measures of water scarcity.

[5]Elhance (1999) argues that countries generally look for unilateral solutions to water problems, before bilateral or multilateral ones are considered.

crops in a given country divided by actual water withdrawals. A high value therefore suggests that little water is being wasted and that irrigation is efficient. In a recent study by (Frenken and Gillet, 2012: 27-29), the average country-level water requirement ratios ranged from 0.18 in Costa Rica, Guinnea-Bissau, and Timor-Leste, to 0.85 in Turkey. This suggests the actual water used to meet the same agricultural demand is about 4.7 times higher in Costa Rica, Guinea-Bissau, and Timor-Leste than it is in Turkey. In other words, the same absolute quantity of water 'goes further' in Turkey than it does elsewhere in the world. An absolute measure would over-predict the degree of scarcity in Turkey, leading researchers to surmise it is more prone to conflict and/or cooperation than its true level of scarcity implies.

The true level of scarcity must also take into account any 'virtual water' imported and exported through trade. As Allan (2001: ch. 5-6) outlines, countries can increase their real water levels by growing crops that require less water and importing those that require more. Countries that do this can thrive with seemingly lower quantities of water than those that do not. In this way, crop decisions and trade profiles alter the amount of water actually available in the long-term.

Focusing on relative scarcity helps alleviate concerns related to cross-basin comparability. In a relative scarcity approach, water availability is defined in relation to some basin-specific baseline. This allows cross-basin comparisons of the size and scale of scarce (or abundant) periods, rather than comparing absolute measures that may or may not mean the same thing in different contexts.

Measures of relative scarcity also implicitly account for the 'human element' of water management without needing to directly measure it. The degree of stress that water scarcity creates depends not only on the hydrological features of the basin, but also on the level of demand for water in the region and changes to natural flows that come from reservoirs and dams. Recognizing this, environmental scientists often consider ratios of water withdrawal or use to discharge (Vorosmarty et al., 2000). Such measures attempt to account for water demand as well as supply. However, withdrawals are difficult to measure directly. Further, if we look at variation over time, actual withdrawals are unlikely to measure true demand in times of water shortage; at such moments, water use is often restricted below the actual level of demand. This downplays the severity of scarcity and biases the measure. In contrast, the concept of relative water scarcity is based on the idea that countries will adapt to their 'normal' level. When that normal level is not reached, incentives for behavior at the international level change. This approach allows us to account for demand without needing to measure it directly.

Despite the theoretical and empirical attractiveness of considering relative scarcity, very little existing research addresses this issue. A few studies, such as those by Gleditsch et al. (2006) and Brochmann and Hensel (2011), include measures of drought in the statistical models. Yet 'drought' is defined in terms of its consequences (e.g deaths, state of emergency declarations), not according to an actual level of relative water availability. Since other factors potentially influence these consequences, including international cooperation or conflict, measures of this kind do not directly capture the degree of relative water scarcity. A slightly different approach is taken by Dinar, Dinar and Kurukulasuriya (2011), who model the average rate of decline in water availability per capita within different basins. This captures the idea of increasing water scarcity over time, but does not account for actual year-to-year variation.

Finally, a few recent studies have focused on how an increase in the variability of water flows might affect interstate relations. De Stefano et al. (2012) examine the institutions that river basins have in place to deal with the issue of variability, and Dinar et al. (2010) look at the relationship between water variability and treaty formation. However, these studies conceive of variability as an attribute of the basin, rather than focusing on country responses to individual extreme events. As water variability increases, countries will more frequently deal with just such extreme events. My approach, which examines how countries react to conditions of such relative scarcity in the short-term, complements these studies of the effects of overall, basin-level variability.

2.2 The predicted effect of water scarcity

It is widely accepted that water scarcity, broadly defined, affects the international behavior of countries that share cross-boundary rivers. However, the exact nature of this effect is less clear. The earliest theories originated with the 18th century writings of Reverend Thomas Malthus (1798: ch. 1-2). He argued that growing population pressure will inevitably lead to violent competition over scarce natural resources. Although technological innovation has kept pace with population growth during the intervening centuries, alleviating some of the predicted pressure, there is a persistent fear that innovation will eventually reach its limit and serious conflict over resources will begin. This argument is particularly germane to the case of water, which is critical for human life and has no substitute. The amount of available water also varies dramatically from region to region, with some areas of the world, such as the Middle East, already experiencing severe shortages. Considerations of this kind led Homer-Dixon (1994: 19-20) to concludes that water is the renewable resource most likely to cause interstate violence. A great deal of research has been conducted in this vein and studies have found some evidence that absolute scarcity, at least, leads to conflict between countries.[6] In essence, the valuable nature of water makes it a resource worth fighting for, and it is significantly more valuable when in short supply.

If the value of water means that absolute scarcity promotes conflict, then a similar relationship should exist between relative scarcity and conflict. After all, the importance of obtaining access to freshwater increases dramatically during periods of shortage. This makes water more valuable and, consequently, more likely to be worth fighting for. Combined with the fact that

[6] See Gleditsch et al. (2006);Tir and Stinnett (2012)

unilateral options are limited, this observation leads to the first hypothesis:

H1: As relative water scarcity increases, countries are more likely to engage in conflictual behavior.

Although conflict is one possible response to water shortages, it is not the only one. Since conflict is always *ex post* inefficient, an *ex ante* agreement will be possible under a wide range of conditions.[7] When water is in short supply, the stakes of determining a mutually-acceptable division of water are higher, making cooperation more likely. A growing body of empirical research supports this prediction for the case of absolute scarcity.[8]

In a similar vein, relative scarcity might induce countries to engage in cooperation rather than conflict. After all, reducing the total amount of available water does not change the fact that conflict is costly. The optimal division of water under conditions of scarcity may be different than it is in periods of abundance, but a mutually-acceptable division should still exist. In periods of relative scarcity, when countries are faced with the desire to obtain water while avoiding conflict and have limited unilateral options for relief, they may come together to determine new water allocations in a cooperative manner. The second hypothesis follows from this observation:

H2: As relative water scarcity increases, countries are more likely to engage in cooperative behavior

To be clear, H1 and H2 are not necessarily mutually exclusive. Water scarcity may simply increase the likelihood that countries take some kind of action. Confirming an empirical correlation between scarcity and conflict, for example, does not explicitly rule out an analogous relationship between scarcity and cooperation. Indeed, some existing studies suggest that water scarcity may have both positive and negative effects on interstate relations. For example, Wolf (2007: 260-262) notes that water can serve as either an irritant or a unifier within an international basin; under some circumstances water may cause relationships to deteriorate and, under others, to improve.[9] Likewise, Hensel, Mitchell and Sowers (2006) find the average annual

[7]This argument is motivated by the reasoning outlined by Fearon (1995: 383-384)

[8]See Tir and Ackerman (2009); Zawahri and Mitchell (2011). Dinar, Dinar and Kurukulasuriya find that cooperation is most likely at intermediate levels of water scarcity (Dinar, Dinar and Kurukulasuriya, 2011).

[9]Brochmann and Hensel argue for a more complicated relationship. They find that water scarcity increases the likelihood of laying claim to the water of a river and the onset of negotiations over existing river claims, but decreases the likelihood that negotiations are successful (Brochmann and Hensel, 2009; 2011).

water usage as a percentage of total renewable resources increases the likelihood of both the onset of a militarized dispute and the likelihood of a peaceful settlement attempt. Following these approaches, I do not consider the two hypotheses in this section to be in conflict with one another.

3 Overview of the case

In this article, I focus on the effects of relative water scarcity in a single hydrological unit: the Aral Sea basin in Central Asia. Restricting attention to one water basin has both positive and negative features. On the positive side, it allows for a more fine-grained analysis of both water availability and the relations between countries. Relative water scarcity is necessarily a short-term phenomenon, since any measure of water availability will converge to its mean when the time frame is large enough. To truly understand the effect of short-term changes on behavior, a short-term measure of scarcity is necessary. By restricting attention to the Aral Sea basin, I am able to use monthly data on relative availability. Doing this captures far more variation than the more commonly used yearly data would, and allows me to examine the effects of relative water scarcity at a low level of aggregation.[10] Furthermore, as I discuss below, this level of analysis controls for a variety of facts that might also influence when and why countries engage one another cooperatively or conflictual. However, this approach also has limitations, the most pressing of which is the degree of generalizability. I address this concern in greater detail in the discussion section that follows the statistical results. While I acknowledge that basin-specific features may influence whether countries interact cooperatively or conflictually, there is far less reason to suspect that country behavior in Central Asia is uniquely sensitive to short-term periods of scarcity. A finding that relative scarcity influences international relations in Central Asia therefore suggests that this will be the case elsewhere as well, even if we cannot generalize about which kind of interaction is more likely.

The Aral Sea is a landlocked body of saline water on the Uzbek-Kazakh border (see Figure 1). Substantial territory of the five post-Soviet Central Asian countries - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan - are located within the Aral Sea's water basin. There are two major rivers: the Amu Darya and the Syr Darya. The Amu Darya originates in Tajikistan and flows through Uzbekistan and Turkmenistan, while the the Syr Darya flows through Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan.[11] With the exception of Kazakhstan, these rivers represent the primary source of freshwater available to the Central Asian

[10] Most studies do not even have yearly data, relying on the assumption that water availability remains relatively constant over time to estimate values for missing years.

[11] The Amu Darya crosses for a short while into Afghanistan and Iran, but neither of these countries have been involved in river management and their withdrawals are minimal (see McMurray and Tarlock, 2005: 730).

Figure 1: Map of the Aral Sea Basin in Central Asia

Micklin P. 2007.
Annu. Rev. Earth Planet. Sci. 35:47–72

countries.[12] It is also, as I will demonstrate, a particularly attractive case for studying the effects of relative water scarcity on the cooperative and conflictual propensities of countries.

During Soviet times, the central government controlled water and energy policy completely, choosing a management system that privileged the agricultural sector and, in particular, the cultivation of cotton.[13] They built large upstream reservoirs, most notably the Toktogul reservoir in the Kyrgyz SSR and the Nurek reservoir in the Tajik SSR, in order to store water during the winter and release it during the growing season, when it was most needed for irrigation. The reservoirs also had the capacity to generate hydroelectricity which, due to the unified electrical grid, could be easily transported throughout the region. In winter, the downstream republics provided their upstream neighbors with the necessary energy resources for heat and electricity. This enabled the Kyrgyz and Tajik republics to store water for the next irrigation season, rather than using it for electricity production during the winter.

After independence, the region-wide system of water and energy resource management faltered, largely because there was no longer an overarching authority to guarantee adherence to a centrally devised plan.[14] The new heads of state began discussing the problem as early as 1992. Although a variety of regional organizations related to water management formed in the immediate post-independence period, by the mid-1990s, a bilateral barter system became the dominant forum for resource management. [15] As Weinthal (2001: 67-72) describes, the linkage of water, energy, and agriculture continued to shape the decision-making process. This means that "cooperation" in the post-Soviet period mimics Soviet era water-for-energy exchanges.[16]

This is not to say, however, that cooperation in the region is easy. Indeed, government leaders often exhibit open hostility towards one another over this issue.[17] For example, in 2012 it was reported that the Uzbek president had directly warned his Tajik and Kyrgyz counterparts of the possibility of war over water (Lillis, 2012: 1). This hostility was also apparent in interviews I conducted in Kazakhstan, Kyrgyzstan, and Tajikistan during 2011-12. In these in-

[12]The north of Kazakhstan has alternative sources of freshwater, but the south is heavily reliant on the Syr Darya

[13]Compliance with this system was not always voluntary; for example, McKinney discusses how, during a drought in the late 1970s, representatives of Moscow were sent to Central Asia to ensure compliance (McKinney, 2003: 194-195)

[14]Without a central authority, trust (and thus cooperation) among the different actors becomes much more difficult to maintain (Abbink, Moller and O'Hara, 2010: 303-304).

[15]See Elhance (1997: 214-217) and Vinogradov and Langford (2001: 350-357) for a description of water management in the early post-Soviet period.

[16]Exchanges did become more complex. Energy was subsidized rather than free, and the purchase of hydroelectricity was also used as "payment" for water. However, the general scheme remained similar.

[17]Speaking earlier in the post-independence period, Smith (1995) predicted that "nowhere in the world is the potential for conflict over the resources as strong as in Central Asia" (p.351).

terviews, subjects from one country often blamed their counterparts in other countries for water or energy shortages. For example, one NGO representative accused another country of "sabotaging the process" of cooperation, while a government official complained that "we do not get any...positive responses to our proposal [for international] cooperation."[18] It is not immediately obvious, therefore, whether water scarcity makes cooperation harder or easier to maintain in the region.

The Central Asian case is well-suited for the study of relative water scarcity for several reasons. First, although the Aral Sea basin represents a single hydrological unit, the fact that it contains two distinct international rivers allows for some cross-unit comparisons. Such comparisons are made even more attractive by similarities between the major rivers. To begin with, they have similar flow geographies: they each cross through several countries, with a predominantly upstream-downstream configuration. Elhance (1999) highlights the importance of both of these geographic features in his cross-basin comparative study and, more recently, Stinnett and Tir (2009) find that rivers with an upstream-downstream configuration are less likely to have high institutionalization (i.e. cooperation) compared to those that feature rivers flowing along borders. In addition to this, the power configuration along the Syr Darya and Amu Darya is comparable. The rivers originate in the mountains of small, poor, and militarily weak countries (Kyrgyzstan and Tajikistan). They then flow through the same, larger, richer, and more powerful, middle country (Uzbekistan) before splitting again and passing through another large and powerful country (Kazakhstan and Turkmenistan). Power configuration features prominently as an independent variable in numerous studies of the water wars and mutual management theories, including those by Mandel (1992), Homer-Dixon (1994), Song and Whittington (2004), and Zawahri and Mitchell (2011).[19] Since the geographies and power configurations are similar, it is possible to set aside the impact of these attributes on interstate behavior and focus more directly on the consequences of water scarcity.

Although there are many similarities between the two rivers, there is one key difference: the Syr Darya has higher absolute levels of scarcity than the Amu Darya: the estimated annual flows are $36.57km^3$ and $78.46km^3$, respectively (Aquastat-FAO, 2013: 4-6). In addition, the Syr Darya traverses the fertile Ferghana Valley, which is responsible for a large part of Central Asia's agricultural production. It is also a densely populated area, further increasing demand on the water supply. For example, in the three Uzbek provinces of the Ferghana Valley - Andijan, Ferghana, and Namangan - this density is 452, 382, and 235 people$/km^2$ respectively. In contrast, the average population density in non-Ferghana Valley Uzbekistan is only $61/km^2$.

[18]The first quote is from an interview conducted in English with representatives of an international NGO located in Kyrgyzstan on 11/2/11 and the second is from an interview conducted in Russian with a Tajik government official on 1/16/12.

[19]Also, see (Wegerich, 2008: 80-85) for a discussion of power politics in the Central Asian case)

Therefore, using a per capita or demand-based measure of water availability would only exacerbate the difference in absolute scarcity. This allows us to look at the impact of relative water scarcity in situations where absolute scarcity has different levels, but other variables are held constant.

In addition, the Central Asian case also features a variety of country-level controls. The countries obtained independence from the Soviet Union relatively recently and, prior to that, were administrated in almost identical ways. Although they have followed different paths since 1991, many similarities in their societal and governmental structures remain.[20] The existing similarities also help account for the more intangible cultural and social factors that may influence propensities for conflict or cooperation. The statistical analysis includes models with dyad fixed effects to control for any remaining dyad-specific features.

Norms concerning the regional water management system also make it easier to observe how relative scarcity affects country behavior. Short-term exchanges of water-for-energy are typically codified in written agreements or contracts and/or reported on in the media. The norm of formalization means that the timing of cooperative interactions can be determined with greater accuracy than if informal arrangements were used, and that violations of these cooperative interactions (i.e. conflictual interactions) are likewise easier to observe. Furthermore, the regularity with which they are signed (and broken) implies there are low transaction costs to both signing new agreements and breaking existing ones. This is crucial for studying the effects of relative scarcity. In order to link a short-term decrease in water with a change in behavior, it is important that the observed behavior represent a response to current incentives rather than a lagged response to outdated ones. Low transaction costs and norms of formalization ensure that both of these are true.

Finally, the unilateral suspension of an existing agreement can be considered a conflictual act in Central Asia. The Soviet water-for-energy system created serious interdependencies among the countries. When initiated by a downstream country during the winter, suspensions cause severe energy deficits upstream, even when hydroelectric production is increased. Residents of these countries subsequently endure electricity rationing - or total blackouts - during the coldest months of the year, threatening both their health and livelihoods. The Soviets actively promoted agriculture in the downstream regions, making them reliant on water from their upstream neighbors. Now, when water is not released in adequate quantities during the growing months, poor farmers in the downstream countries lose their crops and, consequently, their ability to make a living. The antagonistic nature of such suspensions allow us to look at both the positive and negative hypothesized effects of scarcity on country relations within a single

[20]For example, Hensel, McLaughlin-Mitchell and Sowers, and Tir and Ackerman argue that joint democracy may result in higher levels of cooperation within water basins (Hensel, Mitchell and Sowers, 2006; Tir and Ackerman, 2009). However, none of the Central Asian dyads are jointly democratic.

framework.

4 Statistical Analysis

This section outlines the major statistical results of the article. I begin by introducing the main dependent and independent variables and the measures used for each. I then present the results of my analyses. I find that water scarcity is associated with an increased probability of both cooperative and conflictual interactions. I conclude by discussing what these results can tell us about the effects of relative scarcity more broadly.

4.1 Dependent variables

I take an event-based approach to operationalizing both conflict and cooperation because this allows me to capture how countries respond to relative water scarcity in the short-term. For example, the signing of an agreement during a period of shortage, even if not long-lived, suggests that countries responded to the crisis in a cooperative manner. These kinds of events can occur regardless of whether countries are in a generally cooperative or generally conflictual relationship at the time. If, for example, they are already cooperating over resource management, signing a new agreement suggests that they come together to figure out an appropriate division of water under new conditions of shortage in a cooperative manner. Additional cuts to agreed-upon provision of resources, or a refusal to reach agreement, are conflictual events that can occur even if countries are not cooperating fully when scarcity begins.

Events involving both water and energy management are included in the data. As discussed above, these two issues are inextricably linked in Central Asia. Decisions made concerning energy have a direct impact on how water is managed, since the upstream countries will only store water for use in downstream agriculture if they receive adequate supplies of fuel energy during the winter.[21] However, I exclude events concerning conflict and cooperation on other issues. This approach risks excluding certain actions that are affected by relative water scarcity. Linking disparate issues, in either a positive or negative way, is a time-tested tactic in international relations. However, linkages are often difficult to observe, especially they are not made explicit. It would be difficult to systematically identify responses in other issue areas and/or international relations more broadly. However, I do not expect to exclude very many events by

[21]While there are strong theoretical reasons for including both types of events, I also ran models using data that only includes events explicitly related to water and hydroelectricity. The results of these models, which can be found in the Appendix, were similar to those presented below, although the effect of scarcity on conflictual interactions was somewhat stronger than its effect on cooperative ones.

restricting attention to those directly concerning water and energy.[22] Since the linkage between water and energy is so tight, it is more natural for the countries to respond within these negotiating sets than to introduce additional issues (Weinthal, 2001: 72-73). For this reason, I focus solely on water and energy events in the data.

The dataset includes interactions at the dyad-month level for the time period of January 2000 to December 2010. Focusing on monthly interactions allows me to identify short-term changes in behavior, which is crucial for testing the effects of short-term relative scarcity. The time period was selected for a combination of theoretical and practical reasons. It took some time for the Central Asian states to grow accustomed to independence and to learn how to interact with one another as sovereign nations. By 2000, relations between them over water and energy management had, to some extent, been normalized. While periods of transition are interesting in their own right, they are relatively rare, and the theory more directly concerns the ongoing relationships between countries. Focusing on Central Asian relations further into the independence period therefore makes the findings more generalizeable. In addition, while water data was available for the immediate post-Soviet period, the reliability of the event data was not as good. Although there was newspaper coverage of higher-level events (framework agreements, etc.), there was not consistent coverage of short-term agreements and disagreements. By 2000, the events covered by news outlets were at a similar altitude to those found in 2010.

A *cooperative interaction* is defined as the reaching of an agreement with explicit provisions for signatory behavior concerning at least one of the following: (1) prices or terms of payment for energy, including hydroelectricity, (2) the quantity of energy produce to be delivered, (3) the price or terms of payment for water, or (4) the quantity of water to be delivered.[23] I also include situations where lapsed agreements come back into force as a cooperative agreement. The signing of agreements, even if not long-lived, or the resumption of old agreements, following a downturn in water availability both suggest that countries respond to crisis in a cooperative

[22]I was only able to locate two cases where actions in another issue was linked to water issues: in spring of 2001, Kazakhstan shut off telephone lines to Uzbekistan in response to a reduction in flows along the Syr Darya, and in 2010, Uzbekistan prevented railroad cars from crossing in to Tajikistan, apparently in protest Tajikistan's proposed Roghun Dam. This number of events is very small relative to the number that occur within the water and/or energy spheres.

[23]To identify these, I used an extensive search of English and Russian language newspaper articles, supplementing with full text of agreements where possible. The following would be adequate to code the event as a cooperative interaction (although I have more information about many events): "In 2003, Uztransgaz, an Uzbek enterprise is supposed to supply Tajikistan with about 400 million cubic meters of natural gas. The official signing of government-to-government agreements between Tajikistan and Uzbekistan "On mutual accounting for transportation of cargoes, natural gas and fuel supply in 2003" and "Tajikistan's debt to Uzbekistan" will be held in Tashkent, on February 25." (, February 20, 2003)

manner: they come together to figure out appropriate division of water under new conditions of shortage or otherwise make cooperative overtures to their partners. The coding distinguishes between agreements that lay out a clear road-map for the future and those that express more vague statements of interest in cooperation. For example, an agreement that specifies the export price of hydroelectricity for a given year would be considered a cooperative interaction, but a joint statement professing a commitment to "rational use of water and energy resources" would not. I focus on agreements with concrete provisions because I am interested primarily in the actions taken in response to short-term relative scarcity. While more vague agreements may lay the foundation for future cooperation, they are unlikely to impact behavior in the short-term. They are also more likely to be part of broader conferences or agreements, suggesting that the timing will be less dependent on short-term factors like relative water scarcity. However, since agreements are signed with such frequency in Central Asia, and because they mostly have short formal (and often even shorter informal) temporal scopes, even those with concrete provisions represent relatively low levels of cooperation. It is perhaps more accurate to think of them as contracts rather than international agreements. They are clearly cooperative, but they do not require extensive negotiation, or represent a long-term commitment to cooperative resource management.

Three types of events qualify as instances of *conflictual interaction*. The most extreme kind is the occurrence of violence, which occurs only once in the dataset.[24] However, following more recent trends in the literature, I do not restrict attention to the use of violence. While the original Malthusian formulation of the water wars hypothesis predicts exactly what its name implies, using this literal definition of conflict condemns the water wars hypothesis to failure; water scarcity, even if we limit our attention to very extreme levels, is undoubtedly far more common than is the occurrence of full interstate war over water. However, countries can take other coercive actions that unilaterally influence the distribution of available water. Studying the lower-level variants of conflict allows us to determine whether water scarcity has a negative effect on the relationship between countries.[25] This is a valuable enterprise in its own right, since coercive actions of any kind have important political implications and merit study. In addition, current instances of relative scarcity may simply not be as severe as those we will experience in the future (Tarlock, 2008: 709-710). If countries tend to respond negatively at

[24]In March of 2008, there was a clash between Kyrgyz and Tajik citizens over control of a dam. This is included even though it was not government-sanctioned violence. There was also one instance of threatened violence that would not be included in my dataset, since I include only actions and not threats. In this interaction, Uzbekistan pointedly held exercises during the summer of 2001 to practice the takeover of a "well-defended installation" (believed to be the Toktogul reservoir).

[25]Yoffe et al. (2004), Hensel, Mitchell and Sowers (2006) and Hensel and Brochmann (2007) each look at the effect of scarcity on lower-levels of conflict (i.e. not war).

current levels of scarcity, it is reasonable to think that their coercive reactions may escalate into violence under more severe conditions. In light of this, I also include the unilateral suspension of existing water distribution by stopping water or energy flows as a type of conflictual interaction. In coding these suspensions, I look for substantial cuts or nondeliveries.[26] As discussed previously, such suspensions are antagonistic acts in Central Asia and, further, indicate a clear deterioration of relations between the Central Asian countries. It is therefore appropriate to consider this a conflictual action. Finally, I include failed negotiations as conflictual acts. These are not "ongoing" negotiations, but rather situations where negotiations were supposed to reach agreement and did not. While I think it is accurate to describe these failures as conflictual interactions, I present models in the Appendix that exclude them from the definition of conflictual and demonstrate that the main results do not change.

The main dependent variable is a simple indicator variable that takes the value of 1 if an interaction involving the appropriate dyad occurred in a given month. In the statistical section, I look at the occurrence of cooperative interactions, conflictual interactions and any interactions (i.e. either cooperative, conflictual, or both), by using the corresponding indicator variables. More information about the coding rules can be found in the Appendix.

Before proceeding, I should note three things about these data. First, the dataset includes 187 cooperative and 151 conflictual interactions.[27] This is a significantly higher number than in existing datasets. For example, the International Water Event Database lists only 16 events in the Aral Sea basin during the 2000-2008 time period.[28] There are two reasons why my dataset captures a greater number of interactions. First, I include energy management events as well as explicitly water-related ones for the reasons discussed above. Second, by using local as well as international news sources, I was able to gather information on less high-profile events, many of which are dyadic rather than multilateral, but still represent important changes to how these countries interact.

Second, I include all dyads, even those that do not share a river, in the main analyses. The reason for this is again the interrelatedness of water sand energy. Suppose, for example, Kyrgyzstan was able to obtain additional energy from Turkmenistan in a period of scarcity. This

[26]My rule of thumb was 25% reduction or 3-day suspension, although I would occasionally have to take descriptions such as "substantial reduction" at face value.

[27]These are artificially inflated by the fact that energy-related interactions between Tajikistan and Uzbekistan are counted for both the Tajik-Uzbek (Syr) and Tajik-Uzbek (Amu) dyads. However, if we drop, for example, Tajik-Uzbek (Syr) the number of events becomes 139 and 108 respectively. This is still a high number for an 11-year period.

[28]While these events are not coded as dyadic interactions, there are substantially more individual events in my data than in the IWED. Product of the Transboundary Freshwater Dispute Database, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University <http://www.transboundarywaters.orst.edu>.

would decrease reliance on the other Syr Darya countries for energy, raising Kyrgyzstan's bargaining power vis-a-vis these countries and, potentially, resulting in a more favorable allocation of water. However, I do restrict attention to dyads that share rivers when considering the two rivers separately and find that the results are robust to this change.[29]

Finally, it is necessary to acknowledge the possibility of selection bias in these measures: what appears to be instances of cooperation may in fact be simply a codification of coercive relations among the states. In other words, one country may be forced to sign a cooperative agreement favorable to its partner (Zeitoun and Mirumachi, 2008: 303-306). However, I have two reasons for discounting the magnitude of this effect. First, given the water-for-energy exchanges used in the region, neither the upstream nor downstream countries are in a clearly dominant bargaining position. Second, these exchanges have a seasonal dynamic in the sense that upstream countries benefit from cooperation in winter and downstream ones benefit in summer. If one country was dominant, we would expect cooperation to be much more likely, regardless of scarcity, during the season in which that country receives benefits. For example, if the downstream countries were dominant, they would force cooperation in the growing season. I include a growing season control variable in the statistical analysis and, as will become apparent, no consistent pattern of this kind emerges. Therefore, I do not think this kind of bias is significant.

4.2 Independent Variables

The major independent variable is the level of water scarcity *relative to* the 'normal' availability of water. To measure this, it is first necessary to identify 'normal' levels for the Central Asian rivers. To do so, I use data on river flow levels obtained from a database maintained by the Scientific Information Center of the International Coordination Water Commission of Central Asia, which is the major regional organization involved in water management issues. This organization includes delegates from all five countries, suggesting they each had access to the same information on flow levels. Furthermore, it received support and oversight from numerous international organizations during this time period, contributing to the reliability of the data.

The top panels of Figure 2 depicts the average water inflow of water into the two major upstream reservoirs between 1992 and 2010, calculated by month.[30] The dotted lines represent one standard deviation above and below this average. I use these data because flows at any

[29]There are two Uzbek-Tajik dyads in the data- one for the Syr Darya and one for the Amu Darya. Events that involve setting or breaking regulations concerning water delivery are split into their respective dyad. However, events that solely involve energy are impossible to split between the two. These events appear in both the Tajik-Uzbek (Syr) and the Tajik-Uzbek (Amu) dyads.

[30]Data comes from CAWATERinfo, available at www.cawater-info.net.

point below the reservoirs would clearly be affected by the decision of upstream countries to release water. This, in turn, might be affected by the occurrence of cooperative or conflictual interactions at the international level. Since withdrawals upstream of the reservoirs are minimal, the reservoir inflow data should accurately reflect the amount of water available on each river. Thus, I use data on the monthly inflow to the Toktogul reservoir in Kyrgyzstan for dyads along the Syr Darya, and monthly inflow to the Nurek reservoir in Tajikistan to measure the relative availability of water along the Amu Darya.[31] Figure 2 demonstrates that the Amu Darya's flow is significantly larger, especially in the summer months, than the flow of the Syr Darya. As discussed previously, demand along the Syr Darya is also higher, since it passes through the Ferghana Valley, a highly fertile region that is dominated by agriculture. This implies that the absolute level of water scarcity in the Syr Darya is significantly greater than the Amu Darya.

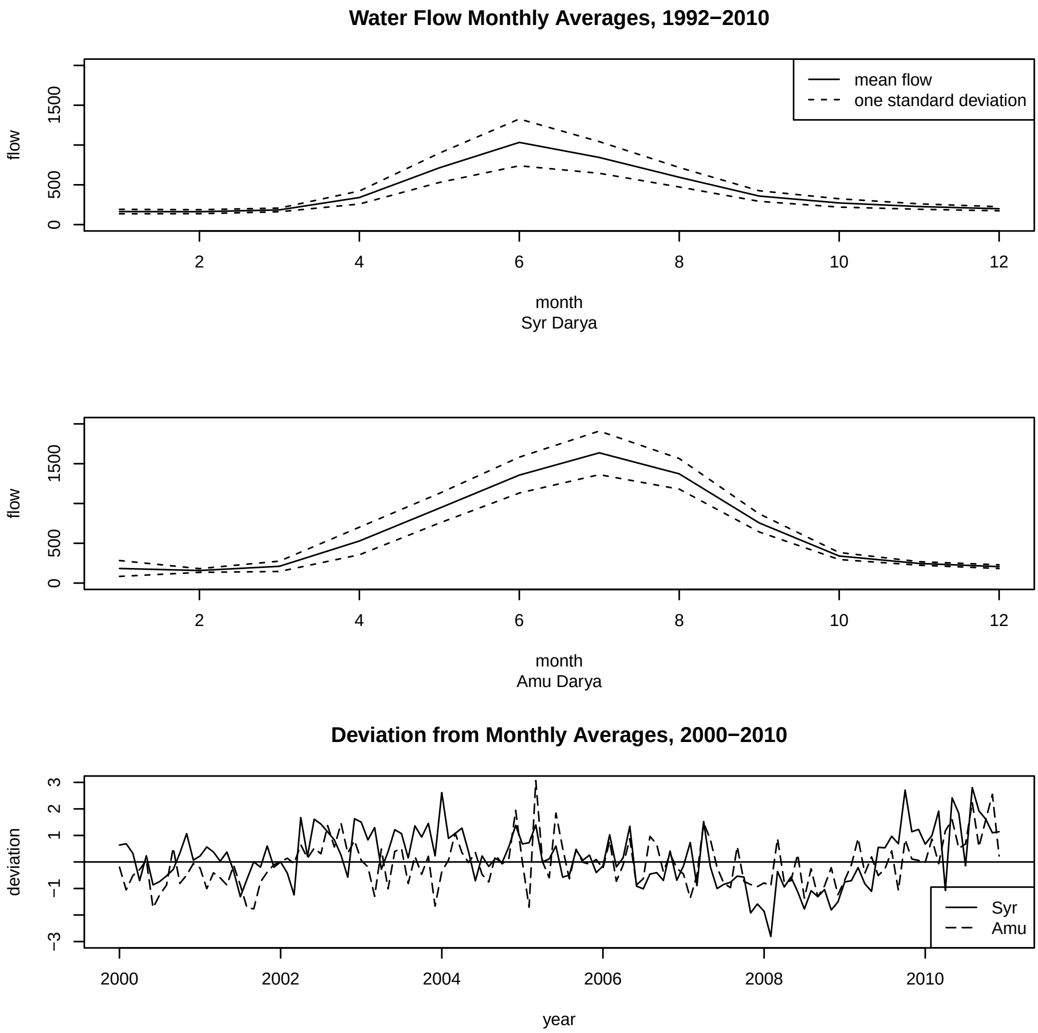
Having identified the baseline availability for each basin in each month, it remains to develop a measure of how scarce water is *relative to this*. Using the inflow data, I construct variables that measure the deviation from the monthly average. For example, I take the average inflow to the Toktogul reservoir in January and then subtract this from the actual inflow in a given January. I then convert the resulting difference into standard deviations. This makes the variable comparable across both basins and months. The bottom panel of Figure 2 displays the resulting measure of scarcity for the 2000-2010 period under consideration. Although there are some differences, the Syr and Amu Darya basins exhibit similar patterns of scarcity and abundance. For ease of interpretation, I multiply the water availability measure by -1 in the statistical analyses, so that a higher value means greater relative water scarcity and a lower value captures decreased relative water scarcity.

This measure of relative scarcity does a good job of capturing droughts of varying lengths and levels: so long as the current month has less water than usual, it will be coded as being scarce. Furthermore, it is possible to look at the cumulative effects of longer-lasting droughts by including lagged or averaged scarcity measures. I take both of these approaches in the Appendix. It is possible, however, that average availability is not stationary over time, but reflects sustained - most likely downward - trends in water availability. For short periods of time, such as the one under consideration here, these concerns can largely be ignored. For studies that cover longer time periods, a model of the long-run trend of water availability, such as the one outlined in Dinar, Dinar and Kurukulasuriya (2011: 5), could be used as the baseline for identifying deviations, rather than just using a simple basin-specific mean.

As previously mentioned, many of the other variables typically used to explain cooperation or conflict within river basins are constant over time in Central Asia. However, I do include

[31] The following dyads use the Syr Darya data: Kyrgyz-Uzbek, Kyrgyz-Kazakh, Kyrgyz-Tajik, Kazakh-Tajik, Kazakh-Uzbek and Tajik-Uzbek (Syr). The following dyads use the Amu Darya Data: Tajik-Uzbek (Amu), Tajik-Turkmen, and Uzbek-Turkmen. The Kazakh-Turkmen and Kyrgyz-Turkmen dyads, which do not share a river, use an average of the two.

Figure 2: Measure of relative water scarcity



a few control variables in some of the statistical analyses. First, I construct history variables for cooperation and conflict. The *history of cooperation* variable is a count of the number of cooperative interactions in the past twelve months. The *history of conflict* variable does the same for conflictual months. Second, I include dyad fixed effects in some analyses to control for any time-invariant factors that make interaction among certain dyads more or less likely. Third, I construct an indicator variable that takes a value of one in the growing season (June - November). In the non-growing season, the benefits of cooperation are enjoyed by the upstream countries and the costs are paid by the downstream countries. In the growing season, however, the reverse is true. This variable controls for any seasonal differences that might result, including the possibility that one country is dominating relations. In some cases I also use an indicator variable that splits the time period under analysis into half. There were some major political changes in the middle of the time period - the Tulip revolution in Kyrgyzstan, the Andijan uprising in Uzbekistan, and (a little later) the death of President Niyazov in Turkmenistan. This variable controls for any broad effects these changes might have on the relationships among countries in the region. Finally, I include a couple of time-invariant indicator variables in the models that do not include fixed effects. The first captures whether the dyad is on the Syr Darya. This controls for any river-specific differences. The second, *exchange* captures whether there was historically a direct exchange between the dyads of water for energy. Included in this are the Kyrgyz-Uzbek, Kyrgyz- Kazakh, Tajik-Uzbek (on both the Amu Darya and Syr Darya), Tajik-Kazakh, and Tajik-Turkmen dyads. We should expect that dyads with these direct exchange connection will interact more frequently than others.

4.3 Results

The core results of the statistical analyses are presented in Table 1. These models examine whether there is a relationship between relative water scarcity and the occurrence of cooperative and/or conflictual interactions. The first model restricts attention to the relative scarcity variable, while the second adds the pertinent controls. The third and fourth models follow the same pattern, but also include dyad fixed effects to control for dyad-specific features and are estimated using a conditional logit model.[32] Water scarcity has a positive and statistically significant effect on the occurrence of both *cooperative* and *conflictual* interactions in all specifications. In other words, countries are more likely to interact with one another - in both a cooperative or conflictual manner - when water is in short supply than when it is abundant.

In order to better interpret these results, Figure 3 displays graphically the effect of water scarcity on the predicted probability of interaction (from Model 2) as scarcity moves from its

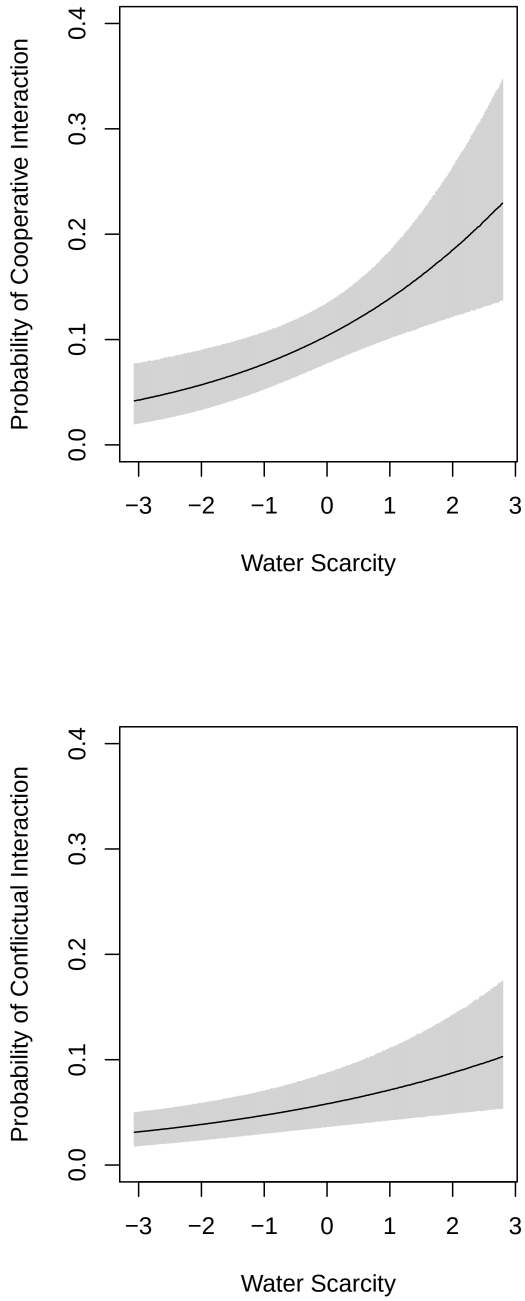
[32]Throughout, these are estimated using the logit.gee model in the Zelig package (Imai, King and Lau, 2007) and the clogit model in the Survival package (Therneau and Grambsch, 2014), respectively.

Table 1: Occurrence of different types of interaction

DV: Coop. interactions	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.328^{***}	0.334^{***}	0.354^{***}	0.370^{***}
	(0.112)	(0.100)	(0.091)	(0.095)
History of coop.		3.509^{***}		0.265
		(0.619)		(0.699)
Growing season		−0.085		−0.090
		(0.187)		(0.176)
Second half		0.024		0.183
		(0.073)		(0.187)
Exchange		0.963^{***}		
		(0.345)		
Syr Darya		0.309		
		(0.375)		
Constant	-1.920^{***}	-3.305^{***}		
	(0.331)	(0.327)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320
DV: Confl. interactions	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.330^{***}	0.216^{***}	0.361^{***}	0.240^{**}
	(0.091)	(0.065)	(0.098)	(0.101)
History of conflict		4.163^{***}		1.815^{***}
		(0.680)		(0.626)
Growing season		-0.395^{*}		-0.428^{**}
		(0.231)		(0.205)
Second half		0.539^{***}		0.841^{***}
		(0.172)		(0.254)
Exchange		1.323^{***}		
		(0.483)		
Syr Darya		0.423		
		(0.472)		
Constant	-2.164^{***}	-4.280^{***}		
	(0.382)	(0.478)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Figure 3: Predicted probabilities of interactions



These figures show the predicted probability of interactions as water scarcity moves from its minimum to its maximum level. The specifications used come from Models 2 in Table 1. All other variables are held at their means minimum to its maximum. This specification includes controls, but no dyad fixed effects. As water becomes more scarce, the predicted probability of any a cooperative interaction increases from 0.039 to 0.231, a gain of 0.192. On the other hand, the increase in the probability of a conflictual interaction is somewhat smaller, increasing by only 0.073 as water scarcity moves from its minimum to its maximum (from 0.031 to 0.104). This suggests that the substantive effect of relative scarcity is larger for cooperative interactions than conflictual ones. Figure 4 illustrates this even more clearly by depicting the predicted effect of moving water scarcity from its minimum to its maximum on the likelihood of cooperative and conflictual interactions respectively. The bars represent the 90% confidence intervals for this prediction. Both confidence intervals are clearly above zero and the predicted effect on cooperative interactions is greater than the effect on conflictual ones (although the confidence intervals do overlap).

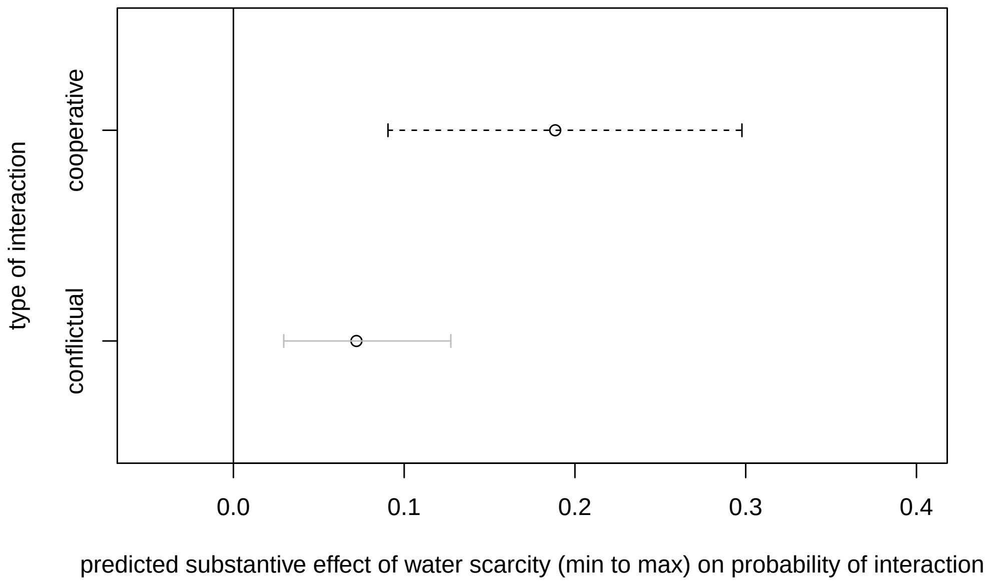
Table 2: Occurence of interactions, split-basin analysis

	Syr Darya		**Amu Darya**	
	Model 1	**Model 2**	**Model 3**	**Model 4**
	coop	**non**	**coop**	**non**
Water scarcity	0.318^{***}	0.231^{**}	0.667^{***}	0.448^{*}
	(0.110)	(0.115)	(0.219)	(0.260)
History of coop.	−0.067		0.079	
	(0.866)		(1.263)	
History of conflict		2.157^{***}		−1.732
		(0.730)		(1.561)
Growing season	−0.117	−0.319	−0.254	-0.893^{**}
	(0.212)	(0.236)	(0.339)	(0.439)
Second half	−0.001	0.565^{**}	0.874^{**}	3.029^{***}
	(0.227)	(0.272)	(0.396)	(0.806)
Fixed effects?	Y	Y	Y	Y
N	720	720	360	360

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
All models are conditional logits with fixed effects.

I also split the sample into the two river basins and performed the same analyses using each subsample. For the Amu Darya sub-sample, I restricted attention to the Tajik-Turkmen, Tajik-Uzbek (Amu), and Turkmen-Uzbek dyads. The Syr Darya sub-sample included the Kazakh-Kyrgyz, Kazakh-Tajik, Kazakh-Uzbek, Kyrgyz-Tajik, Kyrgyz-Uzbek and Tajik-Uzbek (Syr) dyads. The major results are presented in Table 2. These models include the control variables and the dyad fixed effects. As Table 2 demonstrates, a similar pattern emerges in each of the two basins, despite their differences in absolute levels of scarcity. For both the Syr Darya and the Amu Darya, water scarcity is positively associated with the occurrence of both kinds of events, although the effect is larger for cooperative ones than conflictual ones. This provides suggestive

Figure 4: Predicted effect of water scarcity on the probability of interactions



This graphs depict the predicted probability of interaction when water scarcity is at its maximum minus the predicted probability of interaction when it is at its minimum. The bars represent the 90% confidence intervals evidence that, the effect - and certainly the importance - of relative scarcity is consistent across the two different levels of absolute scarcity.

The control variables in both the full-sample and split-basin analyses also reveal some interesting patterns. In general, a history of interaction seems to matter. This variable is positively related to the occurrence of the same kind of interaction (e.g. a history of cooperation is positively related to the likelihood of cooperation) in all of the full basin models except for the fixed effects specification for cooperative interactions. In this case, the identity of the dyad, not its recent history, appears to be what affects the likelihood of cooperation. However, the effect of these history variables is less consistent in the split-basin analysis.

Having a direct water-for-energy exchange relationship increases the likelihood of both types of interaction, as does being a Syr Darya dyad. Conflictual interactions appear more likely in the second half of the time period and are less likely in the growing season, although this effect appears to be driven by the Amu Darya as the relationship does not hold for the Syr Darya subsample.

4.4 Robustness checks

In addition to the major results presented in the previous section, I performed a variety of robustness checks and alternative specifications, some of which are included in this section and the remainder of which can be found in the Appendix.

First, I used alternate specifications of the major variables. I coded three alternative specifications of the main independent variable: one uses the 1992-1999 out-of-sample mean (rather than the 1992-2010 mean) to create the scarcity variable; the second is a three-month average of the relative scarcity variable; and the third is an 'extreme scarcity' measure that takes a value of 1 for scarcity greater than 1 standard deviation from the mean and zero otherwise. The results of these analyses mirror those presented above. Another set of models, also in the Appendix, includes a lagged scarcity variable to capture any lingering effects of scarcity. The main scarcity variable (current month scarcity) follows the same pattern. I also used a stricter definition of conflictual interaction that did not include failed negotiations and the results were also comparable. For another set of models, I control for whether countries are contiguous, rather than having an exchange relationship and find similar results. Finally, I controlled for the absolute difference in per capita energy production in the dyad, to test whether dyads with a greater differential (and thus more reliance of one member of the dyad on the other) exhibited different behaviors. I did not find any effect for the energy differential variable, but the main results concerning water scarcity were unchanged.

Second, I used a multinomial logit model to examine the effect of water scarcity on cooperative and conflictual interactions simultaneously. To do so, it was necessary to code each month as either cooperative or conflictual. If only one interaction occurred, then months are coded

Table 3: Occurrence of interactions, multinomial logit models

		Model 1	Model 2
water scarcity	*cooperative*	0.202** (0.103)	0.198* (0.105)
	conflictual	0.216* (0.119)	0.158 (0.122)
	both		0.668*** (0.159)
constant	*cooperative*	−2.205*** (0.091)	−2.208*** (0.093)
	conflictual	−2.519*** (0.105)	−2.537*** (0.108)
	both		−3.086*** (0.146)
	N	1320	1320

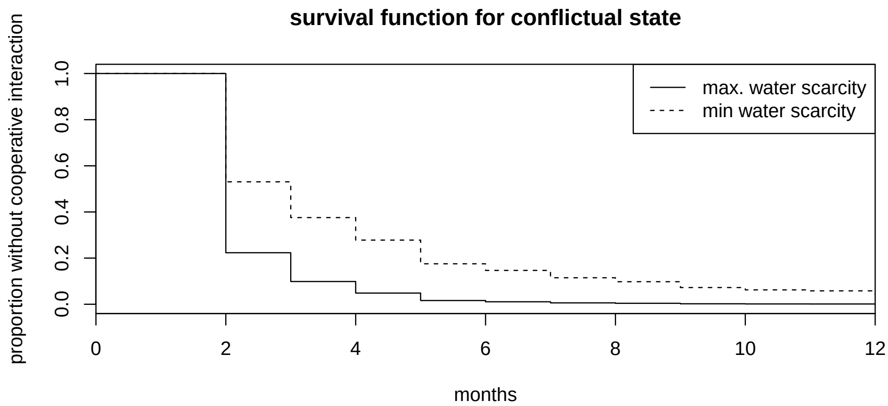
***p < .01; **p < .05; *p < .1

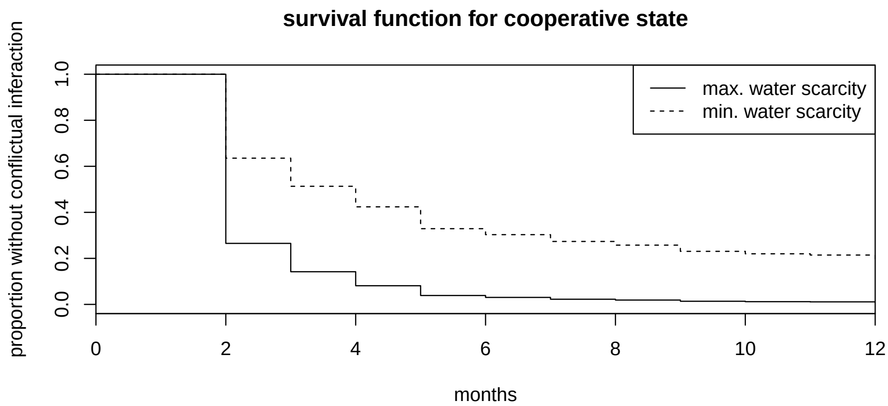
with respect to its type. If no interaction occurs, they are coded as neutral. However, there are 59 dyad-months in which both conflictual and cooperative interactions occurred. In Model 1 of Table 3, these are coded depending on the number of different interactions. For example, if more cooperative interactions occurred than conflictual, the month would be coded as cooperative. If the same number of each occurred, then the month was coded as neutral. Model 1 demonstrates that water scarcity is positively associated with the likelihood of both a cooperative and conflictual month (relative to a neutral one). In Model 2, I include a fourth category for both events occurring. This reveals an interesting pattern: while water scarcity increases the likelihood of cooperation or both events occurring, its effect the likelihood of conflictual interactions *on their own* is not statistically significant. This suggests that when water scarcity causes conflict, that conflict tends to come with cooperation as well. For example, there might be a conflictual act, followed by a renegotiation. Or, alternatively, it might mean there is an attempt at cooperation before one or other of the actors resorts to conflict.

Finally, I examined the effect of scarcity on relationship between countries rather than interactions among them. To do so, I coded the relationships between the countries over time (rather than the occurrence of an interaction). In this coding, a cooperative period ends with the breaking of an agreement. A conflictual period ends with the signing of a new agreement.[33] I then used a Cox proportional hazard model to examine the probability of transitioning between pe-

[33]This coding omits any interactions that are of the same type as the current period.

Figure 5: Survival analyses





riods. The numerical results are in the Appendix, but they are depicted graphically in Figure 5. The top panel of this figure illustrates the survival function for conflictual state - the probability that a cooperative interaction does not occur - when water scarcity is at its maximum and when it is at its minimum. The bottom panel depicts an analogous dynamic for the cooperative state. The takeaway point from this graph is that the the survival functions when water scarcity is at its maximum is below the survival function when it is at its minimum. This means that water scarcity has a substantively important impact on ending both ongoing cooperation (with a conflictual interaction) and ongoing noncooperation (with a cooperative interaction). This effect is statistically significant for both types of interaction.

These robustness checks provide support for the hypothesis that relative water scarcity affects how countries interact: in times of shortage, the Central Asian countries are likely to interact with one another in either cooperative or conflictual ways.

4.5 Discussion

The statistical evidence suggests that the Central Asian countries are more likely to interact with one another when water is relatively scarce, and that these interactions can be either cooperative or conflictual. This finding contradicts the 'cooperation OR conflict' paradigm we often see in the literature and supports more recent arguments that one kind of response does not necessarily preclude another from occurring at another time and under other circumstances.

The finding is particularly interesting because it demonstrates that an increased likelihood of both cooperation and conflict can occur in the same water basin, and even along the same river. A large-n, cross-basin study could not demonstrate this as convincingly: a similar result in such an analysis could be driven by some basins responding cooperatively while others respond conflictually, rather than the same basins responding in both ways. By restricting attention to a single water basin, I disentangle these possibilities and demonstrate that the latter is true for the case of the Aral Sea basin. This speaks to research on foreign policy substitutability (Most and Starr, 1984; Clark, Nordstrom and Reed, 2008), which argues that states are not always constrained to a single policy choice when pursuing particular foreign policy goals, such as obtaining access to water.

However, as with all small-n analyses, we must be careful not to overstate the generalizeability of these substantive findings. Perhaps the Aral Sea basin is unique in responding to scarcity with cooperation and conflict. Indeed, we can point to factors that might incline them to both conflict and cooperation. On the one hand, the fact that water was managed cooperatively under the Soviets may make countries more likely to cooperate; after all, they not only know what cooperation looks like, but have enjoyed the tangible benefits it generates. On the other hand, the fact that the Central Asian countries autocratic and that the downstream actors are "stronger" might incline dyads towards conflict. These competing propensities, unique to the Central Asian case, may explain their mixed response.

I would argue, however, that most basins have some factors that incline them towards cooperation and some factors that incline them towards conflict. For example, India and Pakistan have a history of antagonism that make conflict over the Indus River more likely (Mandel, 1992), but also have a framework agreement in place that might tip the scale towards cooperative responses (Hensel, Mitchell and Sowers, 2006). Likewise, the countries along the Rhine are democratic, which has been associated with cooperative behavior (Tir and Ackerman, 2009). However, the river is considered "high salience," a factor that may make conflictual behavior more likely (Hensel and Brochmann, 2007). There are countless other examples of river basins where "risk factors" for both conflict and cooperation exist. In such situations, we might expect to see a similar substantive effect of relative scarcity on country behavior.

In addition, while the substantive result pushes us to think more deeply about whether conflictual and cooperative responses are mutually exclusive, it is not the only thing we learn from the analyses. More broadly, the findings in this article suggest that *relative* water scarcity plays an important role in determining how countries interact. This result implies that we should not ignore relative scarcity when thinking about how water dynamics affect international behavior. While the same question of generalizeability can be raised for this broader finding, it is far less likely to be case-specific. Nothing about the case of Central Asia suggests that it should be affected more by relative scarcity than other situations. The factor most likely to affect whether relative scarcity matters is the level of absolute scarcity, since it is plausible that relative scarcity only matters in contexts where there is also high absolute scarcity. Yet, the analyses presented here show that relative scarcity matters for both a river with high absolute levels of scarcity (Syr Darya) and low absolute levels of scarcity (Amu Darya). The fact that even rivers with low absolute scarcity respond to fluctuations in relative scarcity also lends credence to empirical approach presented here: it does seem to be true that countries adapt to their "normal" levels of availability and are incentivized to act when these are not reached.

While this article serves as a first step towards understanding how relative scarcity affects country behavior, there remains much to be done on the topic. Future research should explore whether the findings are similar across geographic areas. It would be interesting to see whether a similar substantive result emerge in other international river basins and particularly in those that are beginning to experience increased variability associated with climate change. For example, the Mekong River is currently trying to deal with extreme weather events and resultant river variability.[34] This might be another good case for exploring how relative scarcity affects country behavior.

Furthermore, the distinction between absolute and relative scarcity is important beyond just the issue of water. While not usually framed in these terms, we can see evidence of this division in other kinds of resource endowments. For example, energy can be both scarce in absolute

[34]See www.mrcmekong/topics/climate-change for more information

terms (how much a country produces internally, or is reliably able to import) and in relative terms (a decrease in supply, generally associated with an increase in price). Distinguishing between absolute and relative scarcity in these and other issues can help clarify the effects of different resource endowment shortages.

5 Conclusion

The primary goal of this article was to demonstrate the importance of relative water scarcity for explaining short-term changes in interstate behavior. The existing literature suggests that countries act differently when they face conditions of water scarcity and focuses on one implication of these theories: basins that typically have more water act differently than basins with generally less water. While we have learned much about the relationship between water scarcity and country behavior from this approach, it ignores the effect of short-term changes in water availability within basins. Countries may also face an incentive to change their international behavior during periods of short-term relative scarcity. The evidence presented here suggests that countries do, indeed, respond to short-term periods of scarcity by engaging with their neighbors in predictable ways. Our understanding of how water scarcity impacts country behavior is incomplete without acknowledging this part of the story.

With respect to Central Asia, the statistical results indicate that both cooperative and conflictual interactions between countries are more likely to occur during periods of scarcity. However, there is some evidence that the effect on cooperative interactions is larger and more consistent than on conflictual ones. This result may be surprising to those with knowledge of the region. Government rhetoric about water management is typically virulent, leaving the impression that relations are generally poor. Such rhetoric may play on nationalistic sentiments, but it does not reflect the empirical reality. Cooperation is at least as likely to occur during periods of scarcity as conflict.

The methodology presented in this article could easily be applied to other basins to determine whether the encouraging findings about the relationship between relative scarcity and cooperation in Central Asia are more generally applicable. Like Wolf (2007: 260-262), I would argue that relative water scarcity may have positive effects on relations among countries under some circumstances and negative effects under others. By focusing on water availability relative to a basin-specific mean, the method in this paper allows researchers to evaluate these effects without needing to identify or model domestic demand for water. Understanding how countries react to periods of short-term water shortage will give us a more complete picture of how water availability affects relationships at the international level.

Supplemental Information

Supplemental information, including all data and replication files, are available at https://publish.illinois.edu/shummel/, and at the International Studies Quarterly data archive.

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