Why have some countries on international rivers been successful negotiating treaties? A global perspective

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[1] This paper presents a typology of international rivers based on asymmetries in economic and political power among riparian states. This typology is then used, along with other factors such as the spatial location of riparians on the river, to explore the question of why some riparians on international rivers have been able to successfully negotiate treaties and others have not. The findings lend support to both economic and political economy explanations of cooperative action on international rivers. International rivers with riparians with countervailing economic and political power are far more likely to have negotiated treaties than other river types. Riparian states on international rivers sharing a "western civilization" were much more likely to have concluded treaties than riparian states on rivers in other civilizations. Somewhat surprisingly, rivers that cross "civilization boundaries" appear no less likely to have treaties than international rivers than run entirely through riparian states that share a single civilization. Adjacent upstream/downstream or "side-by-side" riparians were less likely to have concluded treaties than "country pairs" with other spatial relationships. *INDEX TERMS:* 6324 Policy Sciences: Legislation and regulations; 6319 Policy Sciences: Institutions; 6334 Policy Sciences: Regional planning; 6399 Policy Sciences: General or miscellaneous; *KEYWORDS:* international rivers, transboundary waters, water negotiations, water treaties

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1. Introduction

[2] Over the past few years, there has been a growing recognition in the international community of the importance of international waters as a resource for satisfying the world's increasing demands for freshwater [*World Water Forum*, 2000]. Developing the knowledge and skills to cooperatively manage international rivers is one of the great political and environmental challenges of the 21st century [*World Commission on Dams*, 2000]. As water resources professionals ourselves, we wanted to learn more about the policy issues surrounding the search for cooperative solutions to the management of international rivers, and in 2000 we began to read the available literature on the subject. Although there is a large and growing body of case study literature [*Waterbury*, 2002; *Lowi*, 1993; *Allen*, 1996; *Guariso and Whittington*, 1987; *Whittington and McClelland*, 1992; *Wolf and Dinar*, 1994; *Salman and Uprety*, 2002], we were surprised to find that there were few places in the academic or professional literature where one can easily turn for answers to some of the most basic questions about the world's international rivers. However, far and away the best place to begin is the Transboundary Freshwater Dispute Database established at Oregon State University by Aaron Wolf (http://www.transboundarywaters.orst.edu/links) [see also *Wolf et al.*, 1999, 2003]. In particular, we found almost nothing in the literature that offered a global perspective on the factors that affect the likelihood that countries on international rivers will be successful in concluding treaties.

[3] To explore this question of why some riparians on international rivers have been able to successfully negotiate treaties and others have not, we developed a typology that provides a new perspective on the similarities and differences among international rivers. We merged some existing databases and abstracted data from topographic maps, and used all these data to classify the world's international rivers according to our typology. In this paper we first use this typology to determine if some "types" of rivers were more likely than others to have cooperative agreements reached by their riparian states. We conducted a second set of analyses to see if particular types of "country pairs" on an international river were a more appropriate unit of analysis than the type of river itself. Our objective in this article is to share with the concerned water resources professional and the interested reader what we have learned from these analyses, and to stimulate further thinking about the cooperative management of international rivers.

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[4] As our title suggests, we employ a very restricted definition of "success." We simply mean that riparians were successful in concluding their negotiations, i.e., a treaty was signed. This is not, of course, the same as saying that a treaty led to economic and diplomatic outcomes that the riparians or others subsequently judged to be beneficial. In fact, it is entirely possible that we have classified a treaty as "successful" even though the riparians themselves judge the treaty to have been a failure. Conversely, the absence of a treaty may simply mean that a treaty was unnecessary, either because the transboundary water issues were of secondary importance to the riparians, or points of disagreement could be worked out without resort to a formal treaty.

[5] In the next, second section of the paper we summarize current theoretical explanations of why cooperation occurs on international rivers. The third section of the paper presents our typology for characterizing economic and power asymmetries among riparian countries on international rivers. In the fourth section we present the results of our analyses of the question of what "types" of rivers and "country pairs" are more likely to have cooperative agreements. In the final section we offer some concluding remarks about the policy significance of our findings.

2. Background: Theoretical Explanations for Cooperative Behavior on International Rivers

[6] Factors affecting the likelihood of a treaty on an international river can be divided into three categories: socioeconomic, political, and physical (i.e., spatial characteristics of the riparian states on the river). Socioeconomic and political theories about international water management are the most developed. In contrast, little research has examined physical or spatial factors that affect international cooperation in water management. The influence of spatial factors has been explored within the context of transboundary river basins within a single country [e.g., *Sigman*, 2002]. We define a transboundary river basin as a river basin that cuts across two or more political boundaries, but remains entirely within one larger political entity, such as the Ohio River Basin in the United States. While transboundary rivers do share much in common with international rivers that pass through or border more than one sovereign state, they have the advantage of being under one larger political umbrella.

[7] The dominant socioeconomic explanations are based on trade theory, i.e., opportunities to increase economic development through mutually beneficial trade. Trade theory as applied to river basin management is based on the notion that water is a scarce resource (i.e., an economic good) and should be treated in the same manner as any other scarce resource [*Maass et al.*, 1962; *Briscoe*, 1996; F. M. Fisher et al., Optimal water management and conflict resolution: The Middle East Water Project, 2000, http://web.mit.edu/ffisher/www/waterpage/contentpage/waterme.pdf]. As water becomes scarcer, its opportunity cost will increase. The opportunity costs and the value of water will vary in different locations on the river. From an economic efficiency perspective, the ownership of the water is not particularly critical. If two countries share the water in a river, and one country controls most of the water, but the other country has higher value uses of the water, the first country will simply trade water to the second country. The implication is that cooperation (and treaties on international rivers) should occur when reallocating water between countries will result in gains in economic efficiency.

[8] It is often difficult, however, for political elites to separate the economic value of water from its perceived political value. Even in the case of transboundary rivers within the same country, water use rights can become highly politicized leaving little room for economic arguments. For example, the proposed diversion of water from the Roanoke River near the North Carolina/Virginia border to the city of Virginia Beach led to a Federal Court battle and years of litigation. Both sides knew that the economic value of water in Virginia Beach would be higher than any use of water in North Carolina, but the political dispute was over who had the right to the water, not where its economic value was highest. If water use decisions within the United States are so contentious, it should not be surprising if water rights discussions among riparians on international rivers are often highly charged since there is no higher authority to enforce agreements.

[9] In part to deal with the inadequate treatment of equity, sovereignty, enforcement and institutional capacity in economic theories of international river management, scholars have drawn on the fields of political science, international relations, and public administration to offer other theoretical explanations of processes that may lead to cooperation on international rivers. One important question they attempt to answer is how power relations and the level of cross-border integration affect international river management outcomes. A popular approach is the use of game theory, often based on some form of the prisoner's dilemma game in which the countries must decide to extract high or low quantities of water [*Barrett*, 1994; *Kilgour and Dinar*, 1995]. The use of game theory has yielded important insights. As *Barrett* [1998] has shown, players will often accept a suboptimal efficiency result on river basin management if they tie the outcome of the game to other political decisions. This may explain the fact that Pakistan and India were able to reach an agreement on sharing the waters of the Indus even if the treaty was far from optimal from strictly a water resources economic efficiency perspective.

[10] Scholars working with game theoretic frameworks have suggested that countries are more willing to cooperate if they see their relationship as long-term, with constant risks and reliable expectations about others' behavior ("shadow of the future"). If there are fewer riparians (players), they will have an easier time reaching cooperative agreements because of the relatively simpler sanctioning issues. Cooperation is most likely when countries can expect a multilevel game (repeated interaction on the same issue), can employ issue linkage ("fishing rights" in exchange for "irrigation rights"), and the issue is salient in the domestic as well as the international arena. There is also a relatively unambiguous expectation that international rivers with more riparians would have greater difficulty reaching basin-wide cooperative agreements.

[11] Other scholars seeking to understand the socioeconomic and political factors that influence cooperation on international rivers have proposed a number of related theoretical frameworks for understanding shared natural resource management, including regime analysis and global

governance theory. The realists (or neorealists) see cooperation as primarily an extension of power politics [e.g., *Waltz*, 1979]. These scholars posit that cooperation will only occur when one riparian is sufficiently powerful to bend weaker nations to its will and enforce a cooperative agreement. A related argument is that treaties are an extension (or tool) of normal diplomatic behavior focused on balance of power considerations. Each riparian will try to prevent one country from increasing its power relative to others, and treaties on international rivers are simply one means of accomplishing this objective.

[12] Some political theorists argue that cooperation on international issues (especially environmental issues) is more likely when leaders of the epistemic community are strongly involved and can exercise influence in both the domestic and international policy arenas. Epistemic community theorists, such as Peter Haas [see *Haas et al.*, 1994], would anticipate that influential experts from the multilateral development banks and the international water resources community may play a large role in shaping opportunities for cooperative behavior.

[13] *Bernauer* [1997, p. 155] summarizes the view of many political scientists and international relations scholars that "effective management of transboundary freshwater is not merely a legal or technological problem, but rather primarily a political one—that is, a problem of designing and operating effective social institutions to govern the use of freshwater resources." Shared natural resources theory suggests that cooperation is easiest when the number of countries is small, and they have homogeneous preferences. Along these lines, *Bernauer* [1997] suggests several possible variables that determine cooperation among states, including the number of riparians and power disparities among states.

[14] The assumption in shared natural resources theory that homogenous preferences among groups promote cooperative behavior is consistent with *Huntington*'s [1996] argument that countries increasingly identify with their "culture" or "civilization" group rather than with traditional hegemonic powers. Huntington identifies nine large civilization or cultural groupings: Western European, Latin American, African, Islamic, Sinic, Hindu, Orthodox, Buddhist, and Japanese. His argument is that the lines between civilizations are likely to become the main "fault" lines of conflict, with cooperation more likely within a civilization or culture. From this perspective, we would expect to see more treaties on international rivers that fall within a monocivilization and fewer on rivers that cross multiple boundaries between civilizations.

[15] *Wendt* [1999] presents a contrasting perspective on the influence of culture. He suggests that civilization (culture) is at its core neither inherently cooperative nor conflictual. In contrast to *Huntington* [1996], Wendt argues that there is no a priori reason why countries within a civilization would be more cooperative than countries in different civilizations. He maintains that whether or not a state is cooperative or conflictual with respect to others depends on how it views other states within its civilization. He discusses three alternative views of the other: enemy, rival, or friend. In the case of "friend," violence is precluded as a means of settling disputes, and alternative measures, such as treaties, must be sought. Wendt argues that Western European civilization has reached the status of a Kantian friend culture, but that other civilizations are better characterized by a Lockean "rivalry." From this worldview, it is not surprising that Western European civilization has more successful treaties on international rivers than other regions of the world.

[16] Much less attention has been paid in the international waters literature to the possibility that physical or spatial factors (e.g., the percent of a basin that is in each country and the percent of a country that lies in the basin) influence cooperative action. Such factors could be important, however, if the significance of the river to each riparian affects the likelihood of a treaty outcome. Scholars have addressed the question of whether the saliency of water resources to a country will have a positive or negative impact on cooperation. One common argument is that as scarcity increases, so will conflict, thereby making cooperation more difficult. *Bernauer* [1997, p. 162], for example, asserts that scarcity and poor quality of water resources lead to increased conflict because countries are dependant on those water resources. Alternatively, scarcity could increase willingness to cooperate because the consequences (costs) of losing water in a conflict would increase.

[17] Drawing on these theoretical discussions from different disciplines, we have four hypotheses about how all three sets of factors (economic, political and physical) affect the likelihood that cooperative agreements have been reached by riparian states on international rivers.

[18] Hypothesis 1 is as follows: Treaties are most likely on international rivers where the riparian states have different comparative advantages and could gain the most from trade.

[19] Hypothesis 2 is as follows: Riparian states near each other geographically (i.e., spatially) will be most likely to cooperate, other things equal, because the transaction (transportation) costs of trade should be lowest.

[20] Hypothesis 3 is as follows: Riparian states with different cultures are less likely to cooperate because the transaction costs will be high.

[21] Hypothesis 4 is as follows: Treaties are more likely to occur when a powerful state can exert its influence on weaker states. Powerful states may find international treaties instrumentally useful for their water resources development because an appearance of international cooperation may facilitate international financing, or powerful states may judge that it would be a propitious time to conclude an international treaty (i.e., while they are strong). Conversely, states with similar economic and political power may (1) already be in a "balance of power" equilibrium, and thus have less need for a treaty as a tool of diplomacy, (2) have less reason to negotiate a treaty to exploit comparative advantages, and (3) have less ability to push a treaty to conclusion.

[22] At a minimum, testing these hypotheses requires variables that measure a state's economic and political power and describe the location of riparian states on the international river.

[23] In the remainder of this paper we test these hypotheses about the determinants of cooperative behavior with data on international rivers and their riparian countries. Of course, a myriad of different relationships exist between riparian countries on an international river, and it is impossible to fully characterize these relationships in any simple,

one-dimensional way. Each international river system is in many respects unique, in terms of its hydrology, history, ecology, cultures, economies and political systems. Yet there are certain characteristics of rivers shared by more than one country that enable us to measure economic and political asymmetries between riparian states that can form the basis of useful typologies, which can in turn be used to test the four hypotheses above.

3. Methodological Approach

[24] This third section of the paper presents a simple typology of the world's international rivers that we use to explain the likelihood of "successful" treaty negotiations. Our typology is grounded on two of these theoretical explanations, one based on economic reasons for cooperative action and the other on political reasons. We also consider the role that physical characteristics of the river (e.g., size and geographical location) may play in affecting cooperative behavior, for example, by either enhancing economic opportunities or exacerbating political difficulties. Our typology focuses on each riparian country's population (a proxy for political power), average gross domestic product (GDP) per capita, the number of riparian countries on a river, and the location of riparian countries on the river. Combined with information on which continent an international river is in and the spatial pattern of states on the river, this typology can help us examine the effect of both political economy and geography on the likelihood of "successful" treaty negotiations.

[25] We chose to classify rivers in our typology rather than separately test GDP per capita and population for two reasons. First, the typology itself can provide a new way of considering international rivers. Second, the typology can help us capture the interaction between GDP per capita and population size. Measuring a country's economic strength in terms of GDP per capita is relatively uncontroversial; equating a country's political power with the size of its population is more problematic. It is, however, commonplace for political leaders themselves to associate population size with political strength. Historically a larger population size has given the state a larger resource base upon which to draw both military personnel and taxes [*Olson*, 2002].

[26] We have categorized the different patterns of economic and population asymmetries between countries on an international river into three main groups. Group 1 (comparable economic situation and population size) includes rivers in which all riparian states have comparable economic situations and population (no difference between riparian states is greater than two times). In other words, for each river we compare the absolute difference in the GDP per capita of each pair of riparian states. For a river to be classified in group 1 the absolute difference between the GDP per capita of each possible pair must be less than two. We then make the same pairwise comparisons for the total population of the riparian states. All the population comparisons must also have an absolute difference of less than two for this river to be classified in group 1. Using a "2X" criterion is admittedly ad hoc, and we experimented with different values. Below 1.8X, almost no rivers fell into group 1. Above 3X, there was little variation in the classifications.

[27] Group 2 (countervailing economic situation and population size) includes rivers in which there is no clear hegemon (as used in this paper, a country is a hegemon if it dominates in the sense that its population and/or GDP per capita is at least two times greater than that of every other riparian state on the river) in terms of economic strength or population and at least some riparian states have countervailing power (i.e., if one riparian is stronger in terms of population size (at least two times difference), another riparian is stronger economically (at least 2 times difference).

[28] Group 3 includes rivers with a dominant riparian. In group 3 we identify three distinct situations. Group 3a (comparable economic situation but dominant population size) is where the riparians have similar economic situations, but one riparian has a much higher population than the other(s). Group 3b (comparable population size but dominant economic situation) is where the riparians have similar populations but one riparian has a substantially higher GDP per capita. Group 3c (dominant economic situation and population size) is where a "super" hegemon has both a larger population and a stronger economy. Within groups 3a–3c, we further classify rivers depending on the location of the hegemon on the river, i.e., whether the hegemon is an upstream, midstream, or downstream state. Upstream hegemons are typically in an even stronger geopolitical position than downstream or midstream hegemons.

[29] In a two-country river such as the Mississippi, there is only one country pair, the United States-Canada. In a four-country river such as the Amur there are, however, six possible country pairs: Russia-China, Russia-Mongolia, Russia-Korea, Dem., China-Mongolia, China-Korea, Dem., and Mongolia-Korea, Dem. Any one or more of these pairs might be involved in a treaty on the Amur. When we use country pairs as the unit of analysis on a river, we are further able to classify these pairs in terms of their geographical location with respect to each other and the international river of interest. Each country pair can be classified as adjacent upstream/downstream; side by side; adjacent upstream-downstream and side by side; nonadjacent upstream/downstream, and nonadjacent, not upstream/downstream (Figures 1a–1e). We include nonadjacent country pairs in our analysis because disputes or cooperation on an international river do not always have to take place between two adjacent countries. In Appendix A we show the results of applying our typology to 12 of the world's largest international rivers, and then compare the findings from one region of the world with those from others.

[30] If cooperation is more likely on international rivers where the riparian states have different comparative advantages and could gain the most from trade (hypothesis 1), one would expect to find more treaties on group 2 rivers with countervailing hegemons. If cooperation is more likely to occur when a powerful state can exert its influence on weaker states, we would expect to see cooperative agreements on group 3a, group 3b, and particularly group 3c rivers (hypothesis 4). Similarly, riparians on group 2 rivers might prefer a cooperative agreement that "balances" their relative power positions and prevents one state from gaining an advantage if there were no treaty. Likewise, riparians on group 1 (comparable) rivers would have little incentive to reach a cooperative agreement if the balance of power

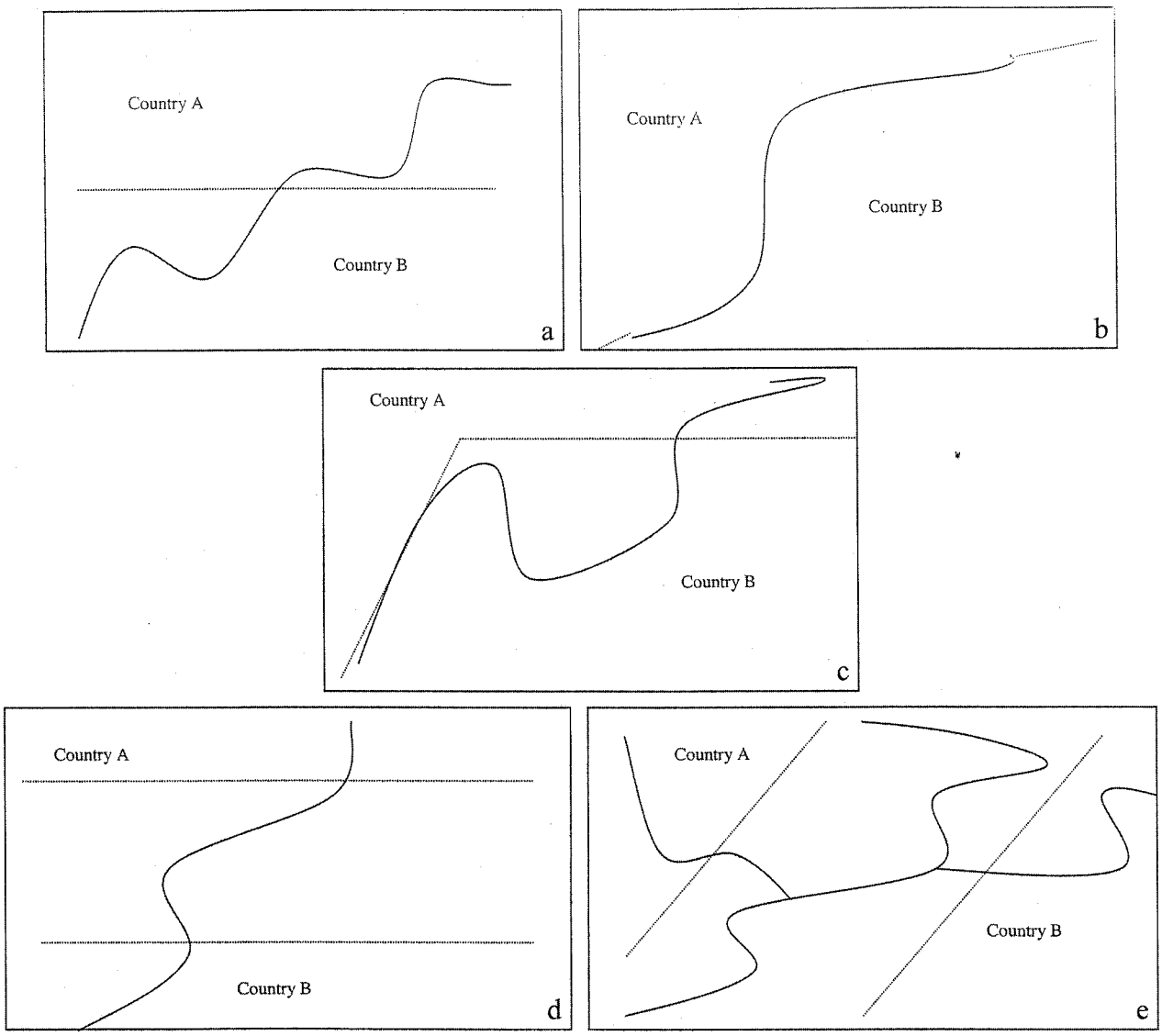

Figure 1. Country pairs: (a) adjacent upstream/downstream; (b) side by side; (c) adjacent upstream/downstream and side by side; (d) nonadjacent upstream/downstream; (e) nonadjacent, not upstream/downstream.

among these states were stable, and no state appears poised to improve its position vis-à-vis its neighbors (hypothesis 4). From this balance-of-power perspective, small countries on group 3a, 3b, and 3c rivers would be less likely to arrive at cooperative agreements because other riparian states might fear that the dominant state would have too much influence dictating the terms of the agreement, thus leaving them in a relatively worse position.

[31] This typology is just one simple way of looking at the economic and power asymmetries on the world's international rivers; there is much that it does not capture. For example, it does not take into account (1) the volumetric contribution of water that different riparian states make to the total flow of the river, (2) the length of the international river that runs through a given riparian country, or (3) the extent to which each riparian country depends on the international river for its water resources. It also does not explicitly capture asymmetries in military power. Another possibly important factor that it does not capture is type of legal system, such as Islamic law, Roman law and northern European water law (although the differences in legal systems may be closely correlated with Huntington's civilization groups). The same caveats exist when applying our typology to country pairs as they do for international rivers themselves.

[32] In addition to this typology, we developed measures of other factors that were hypothesized to affect the likelihood of successfully concluding treaty negotiations on international rivers. To measure the physical attributes of a river, we included variables on continent and geographic relation of the riparian states (each country pair can be classified as adjacent upstream/downstream; side by side; adjacent upstream-downstream and side by side; nonadjacent upstream/downstream, and nonadjacent, not upstream/downstream (Figures 1a–1e)). We use these spatial variables to test whether riparians that are geographically close to each other are more likely to negotiate a treaty (hypothesis 2). We

Table 1. Description of Variables Used in the Multivariate Analysis of Successful Treaty Negotiations

Variable Name	Description	Mean and Standard Deviations of Variables
#RIPARIAN	identifies the number of riparian states on an international river	3.10 (2.11)
GROUP1	1 = if the riparian states have similar (less than 2X difference) GDP per capita and population size 0 = otherwise	0.09 (0.29)
GROUP2	1 = if the riparian states have countervailing GDP per capita and population size; i.e., one state dominates in GDP per capita (at least 2X difference) and another state dominates in population size (at least 2X difference) 0 = otherwise	0.22 (0.42)
GROUP3a	1 = if one riparian state dominates the others in population size, but all states have similar GDP per capita 0 = otherwise	0.44 (0.50)
GROUP3b	1 = if one riparian state dominates the others in GDP per capita, but all states have similar populations. 0 = otherwise	0.06 (0.24)
GROUP3c	1 = if one riparian state dominates the others in both GDP per capita and population size 0 = otherwise	0.19 (0.39)
AFRICA	1 = if the river is in Africa 0 = otherwise	0.29 (0.45)
ASIA	1 = if the river is in Asia 0 = otherwise	0.23 (0.42)
EUROPE	1 = if the river is in Europe 0 = otherwise	0.25 (0.43)
S AMERICA	1 = if the river is in South America 0 = otherwise	0.18 (0.38)
N AMERICA	1 = if the river is in North America 0 = otherwise	0.07 (0.26)
WESTERN	1 = if the river is in the Western civilization 0 = otherwise	0.16 (0.37)
LATINAMER	1 = if the river is in the Latin American civilization 0 = otherwise	0.14 (0.35)
AFRICAN	1 = if the river is in the African civilization 0 = otherwise	0.12 (0.32)
ISLAMIC	1 = if the river is in the Islamic civilization 0 = otherwise	0.10 (0.30)
ORTHODOX	1 = if the river is in the Eastern Orthodox civilization 0 = otherwise	0.05 (0.22)
MULTIPLE	1 = if the river crosses more than one civilization 0 = otherwise	0.41 (0.49)

also looked at the number of riparian states on a river, which can serve as a proxy for river size as well as an indicator of political complexity.

[33] The political and cultural relationships between the riparian states on a river are more difficult to measure. The approach we took was to create a set of variables that depicts the predominant civilization types suggested by Huntington. We created a new variable to characterize rivers that cross civilization boundaries, and use this to test whether riparian states with different cultures are less likely to cooperate (hypothesis 3).

4. Results of the Multivariate Analyses: International Rivers and Country Pairs

4.1. On What Types of International Rivers Are Riparians Most Likely to Have Succeeded in Reaching Agreements?

[34] To see whether the river classifications (groups) created with our typology could help us better understand what "types" of rivers are more likely to have cooperative agreements among riparian countries, we first conducted a multivariate analysis using data from the largest 200 international rivers in the database. We limited our analysis to the largest 200 international rivers because there were very few treaties on the smallest rivers, and it would seem that in most cases the smallest international rivers were simply not as important to the riparians as the larger rivers. The multivariate models attempt to explain the likelihood of a river having a treaty since 1950 (among any of its riparian states) as a function of four independent variables: (1) continent in which the river is located; (2) the number of riparian countries; (3) whether all riparian countries on the river share a broad common civilization or culture; and (4) the river's typology classification based on GDP per capita and population size. The reader should note that these models do not include any policy variables. We would have liked to have had information on such policy variables as (1) the level of resources riparians devoted to the treaty negotiation process, (2) the assistance of outside parties in aiding the negotiation process, and (3) level of funding from parties outside the river basin for implementing the provisions of the treaty. However, we were unable to assemble data for any such policy variables. This is likely a fruitful area for future research. Table 1 presents a description of the variables used in the multivariate analyses that use the river as the unit of analysis, and presents their means and standard deviations.

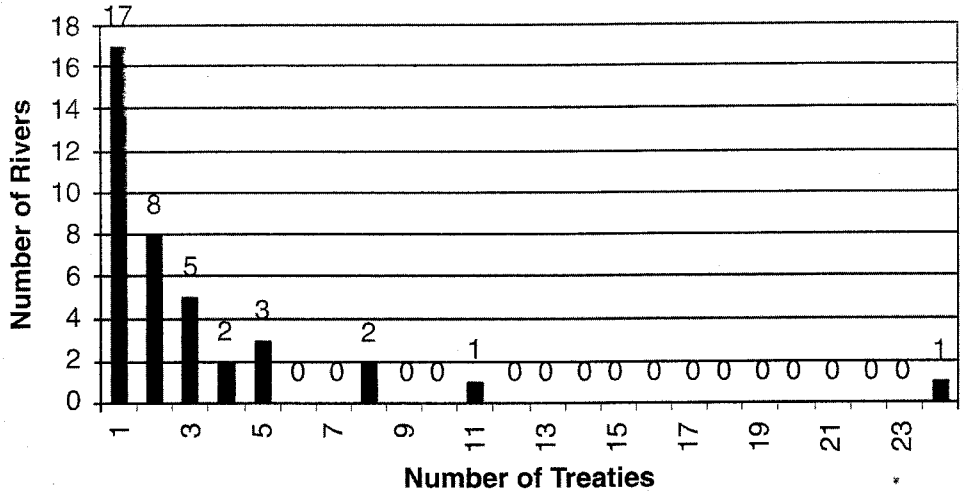

Figure 2. International rivers with one or more treaties.

[35] In this analysis the Japanese civilization was excluded from Huntington's civilization categories because Japan does not share any international rivers. Likewise, the Hindu and Buddhist civilizations were also excluded because there are no international rivers exclusively in these two civilizations. The Sinic civilization was eliminated because it had too few international rivers (3) to include in the analysis. International rivers in this "Chinese" civilization were not ignored, however; the majority cross more than one civilization and are captured by our "multiple civilization" variable. Since these civilization types overlap with (but are not identical to) continents, in our multivariate models we could not use both continents and all the civilization types.

[36] We used three alternative definitions for the dependent variable in the model. The first was a dichotomous variable that indicated whether or not the river had a treaty signed since 1950. (The date on treaties came from two sources: (1) The Transboundary Freshwater Dispute Database, http://mgd.nacse.org/qml/watertreaty; and (2) a comprehensive search of the literature on environmental resource law.) The second was a count of the number of treaties on each river. The third was a categorical variable that indicated whether or not a river had zero treaties, one treaty, or multiple treaties. Our unit of analysis in this first set of multivariate results was thus the river. It was not necessary that a treaty include all riparian countries to "count" in our analysis (e.g., if a river had three riparians, and there was one treaty since 1950 between any two of them, we considered this river to have a treaty).

[37] As shown in Figure 2, of the 200 largest international rivers, 161 do not have any treaties or agreements. Of those rivers that do have treaties, seventeen rivers have one treaty, eight rivers have two treaties and fourteen rivers have three or more treaties (for a total of 122 treaties). It is important to note that our definition of treaty captures only bilateral and multilateral cooperative agreements for specific rivers; it does not include global or regional nonriver specific agreements such as the Convention on the law of non-navigational uses of international watercourses or the regime proposed by the Southern African Development Community [*United Nations*, 1997; *Salman*, 2001]. Nor does it capture cooperation on rivers that does not involve a formal agreement [*World Bank*, 1994].

[38] Table 2 shows the number and percent of treaties for rivers in different classifications of our typology. Of the 200 largest rivers, 19 are classified as group 1 (comparable economic and population situation), but only three of these have treaties. There are 42 group 2 rivers (countervailing situation); these have 53 treaties. There were 90 group 3a (population hegemon) rivers, but these have only 33 treaties. There are only 11 group 3b (economic hegemon) rivers with only 1 treaty among them. There were 37 group 3c (population and economic hegemon) rivers with 32 treaties.

[39] Table 3 presents the results for three model specifications for a logit model with the dependent variable "treaty/no treaty." The data set of treaties was limited to treaties signed during or after 1950. Classification of a river with a treaty was based on the GDP per capita and population for the year the treaty was signed. In 15 cases, data were incomplete, and the current typology was used. Most rivers have maintained the same classification over time. Models estimated using the other two dependent

Table 2. Rivers and Treaties by River Typology

	Number of Rivers	Percent of Rivers	Number of Treaties	Percent of Treaties
Group 1: Comparable	19	9.5	3	2.5
Group 2: Countervailing	42	21.1	53	43.4
Group 3a: Population hegemon	90	45.2	33	27.0
Group 3b: Economic hegemon	11	5.5	1	0.8
Group 3c: Population/economic hegemon	37	18.6	32	26.2
Total	199	100	122	100

Table 3. Multivariate Models of the Determinants of Concluding Treaty Negotiations, Logistic Regression With Binary Dependent Variable

Independent Variables	Continent Model	Civilization Model	Combination Model
Intercept	−3.59 (1.24)	−2.28 (1.15)	−3.58 (1.25)
#RIPARIAN	0.42[a] (0.11)	0.40[a] (0.12)	0.43[a] (0.11)
Typology			
Group2	2.52[b] (1.19)	3.21[a] (1.19)	2.74[b] (1.22)
Group3a	0.83 (1.20)	1.01 (1.13)	0.99 (1.21)
Group3b	1.29 (1.57)	1.92 (1.58)	1.61 (1.60)
Group3c	1.84 (1.20)	2.16[c] (1.15)	2.05[c] (1.22)
Continent			
AFRICA	−1.41[b] (0.61)		−1.48[b] (0.62)
ASIA	−0.69 (0.55)		−0.69 (0.56)
S AMERICA	−1.81[b] (0.90)		−1.88[b] (0.90)
N AMERICA	0.75 (0.74)		0.68 (0.73)
Civilization			
LATIN AMER		−2.91[b] (1.19)	
AFRICAN		−2.89[a] (0.92)	
ISLAMIC		−1.68[b] (0.82)	
ORTHODOX		−2.38[c] (1.28)	
MULTIPLE		−1.92[a] (0.62)	−0.47 (0.46)
Likelihood ratio	54.52 ($p < 0.0001$)	56.44 ($p < 0.0001$)	51.94 ($p < 0.0001$)
Percent correct prediction	82.0%	82.6%	82.6%

[a]Significant at 0.01.
[b]Significant at 0.05.
[c]Significant at 0.10.

variables yield similar results. In model 1 we focused on a geographical division of international rivers by continent. Model 2 is a "civilization" model in which we replaced continent designations with the restricted set of Huntington's civilization types described above. Model 3 combines information on both continents and civilizations by using continents as the base, but includes an independent variable for "civilization" that denotes whether all the riparians on a river belong to one of Huntington's civilization categories, or whether some riparians belong to one civilization and others belong to another. The base case for our river classification was group 1, for continent it was Europe and for civilization it was Western.

[40] The results from all three models indicate that an international river in Africa or South America is less likely to have a treaty than a river in Europe (the parameter estimate for Asia is negative but not statistically significant.). A river with riparians entirely from Latin American, African, Islamic, Eastern Orthodox civilizations, or a river with riparians from more than one civilization, is less likely to have a treaty than a river exclusively within Western civilization. However, there was no statistical difference between a river with multiple civilizations and any of the other civilizations (i.e., Latin American, African, Islamic, Eastern Orthodox), excluding Western.

[41] In model 1 four independent variables are statistically significant (number of riparians, group 2, Africa, and South America). In model 2, the civilization model, eight independent variables are statistically significant (number of riparians, group 2, group 3c, and all of the civilization variables). In model 3, the combined model, the independent variables number of riparians, group 2, group 3c, Africa, and South America are statistically significant. The increased likelihood of a treaty as the number of riparian states increases should probably not be viewed as evidence against the hypothesis that cooperation becomes more difficult with multiple players, but could simply reflect the increased number of opportunities for cooperation on a given river.

[42] Compared to group 1 rivers (comparable population and economic situations), international rivers in group 2 (countervailing power), and group 3c (rivers with a population and economic hegemon) are more likely to have a treaty. Being in groups 3a and 3b does not have a statistically significant effect compared to group 1. As shown in Table 4, other things being equal, a river in group 2 is approximately 12–25 times more likely to have a treaty than a river in group 1.

4.2. What Types of Country Pairs are More Likely to Have Successfully Concluded Treaties on International Rivers?

[43] In the analysis discussed above, each river was classified as having a treaty even if only two of several riparian states actually participated in the agreement, and we focused on the question, "On what type of river are riparians most likely to reach a cooperative agreement?" We now ask whether it is the river type that most influences the likelihood of a treaty, or is it the type of country pair that is instead the key determinant of whether or not the riparians were able to successfully negotiate a treaty? Using country pairs enables us to look at treaty agreements at a bilateral level. Note that in the case of a multilateral treaty agreement, this would register in the country pair data set as a series of bilateral agreements. A country pair represents the smallest unit for a cooperative agreement. We looked at each of 685 country pairs in the data set of 200 international rivers as a distinct opportunity for a successful treaty negotiation. This analysis allows us to examine whether the "type" of country pair and its spatial characteristics might also affect the possibility of a treaty.

[44] The results of the analysis of country pairs must, however, be interpreted with caution. The characteristics of specific country pairs could be important because bilateral

Table 4. Odds Ratios of the Determinants of Successful Treaty Negotiations

Independent Variables	Continent Model	Civilization Model	Combination Model
#RIPARIAN	1.52 (1.23–1.89)	1.49 (1.17–1.88)	1.53 (1.23–1.92)
Typology			
GROUP 2	12.40 (1.19–128.69)	24.75 (2.42–252.72)	15.55 (1.42–170.75)
GROUP 3a	2.30 (0.22–24.02)	2.74 (0.30–25.18)	2.69 (0.25–28.65)
GROUP 3b	3.65 (0.17–39.30)	6.83 (0.31–149.75)	5.01 (0.22–115.53)
GROUP 3c	6.30 (0.60–66.47)	8.64 (0.90–82.88)	7.80 (0.71–85.17)
Continent			
AFRICA	0.24 (0.07–0.80)		0.23 (0.07–0.77)
ASIA	0.50 (0.17–1.47)		0.50 (0.17–1.52)
S AMERICA	0.16 (0.03–0.96)		0.15 (0.03–0.89)
N AMERICA	2.13 (0.50–9.00)		1.98 (0.47–8.27)
Civilization			
LATIN AMER		0.05 (0.01–0.56)	
AFRICAN		0.06 (0.01–0.34)	
ISLAMIC		0.19 (0.04–0.94)	
ORTHODOX		0.09 (0.01–1.13)	
MULTIPLE		0.15 (0.04–0.50)	0.63 (0.26–1.53)
Percent correct prediction	82.0	82.6	82.6

relations between two countries on rivers with many riparians may simply be more important than other multilateral relationships. It could also be the case that negotiations between country pairs are part of a larger set of strategic, balance of power considerations involving other riparians. Our analysis does not permit us to distinguish between these two motivations for bilateral treaties.

[45] We examined the effect of five independent variables on the likelihood of a particular country pair having a treaty: (1) the typology classification of the country pair; (2) the typology classification of the river on which the country pair is located; (3) the civilization of the countries in the country pair; (4) the continent where the country pair is located; and (5) the geographical (spatial) relationship of the two countries on the river (Table 5). For the two typology classifications we created a joint variable that described both the country pair and river type (e.g., a group 1 country pair on a group 1 river). This led to only 15 possible classifications because a number of country pair types and river types did not occur together or occurred too infrequently to include in the model. For example, on group 3b rivers, almost all the country pairs were group 3b as well. The civilization variables used in the river model remain the same, but when applied to country pairs we were able to add two additional civilization variables: Sinic and Buddhist. We included variables to characterize the five possible kinds of spatial relationships between two countries on a river noted above.

[46] Table 6 shows how the 685 country pairs in our data set and the treaties that they share are distributed over our typology classifications. From the set of 685 country pairs, 268 had a total of 534 treaties; the remaining 417 country pairs did not have treaties. In many cases the 534 treaties reflect the bilateral consequences of multilateral treaties. Table 6 also shows that the percentage of treaties is fairly evenly distributed among the types of country pairs. Unlike the situation with our river classification, group 2 country pairs actually account for a lower percentage of treaties than any other group.

[47] Table 7 presents the results for three specifications of a logit model, again using the dependent variable "treaty/no treaty." As in the river models, we limited the data set to the 200 largest rivers and to treaties signed during or after 1950. For comparison purposes, our three model specifications mirror those presented in the previous section. In model 1 we focused on a geographical division of country pairs by continent, with Europe as the base case. Model 2 is a "civilization" model in which we replaced continent designations with Huntington's civilization types, with Western civilization as the base. Model 3 combines information on both continents and civilizations by combining the continent variables with a civilization variable that denotes whether both countries in a country pair belong to the same civilization or whether they belong to multiple civilizations. All three model specifications include the independent variables for river/country pair type and geographical relationship of the country pair, with "river group1/country pair group 1" and "adjacent upstream/downstream" as the base cases.

[48] The results of models 1 and 3 indicate that country pairs in Africa or Asia are less likely to have a treaty than a country pair in Europe (the parameter estimates for South and North America are negative but not statistically significant.). In model 1, 13 independent variables are statistically significant (all country pairs on river group 2; all country pairs on river group 3c except county pair 2; Africa; Asia; and the spatial variables "not touching, not upstream/downstream", and "upstream/downstream but not touching"). In model 2 (the civilization model) 14 independent variables are statistically significant (all country pairs on river group 2; all country pairs on river group 3c except country pair group 2; all the civilizations and cultures, including multiple, nonadjacent, not upstream/downstream and nonadjacent upstream/downstream). In model 3 (the combined model) the following independent variables are statistically significant: all the country pairs on river group 2; all the country pairs on river group 3c except country pair group 2; Africa, Asia, Multiple civilizations; and the spatial variables "not touching, not upstream/downstream" and "upstream/downstream but not touching." The results also indicate that a country pair with riparian states entirely from Latin American, African, Islamic, Sinic, Buddhist, Eastern Orthodox or Multiple

Table 5. Description of Additional Variables Used in "Country Pair" Analysis of the Determinants of Concluding Treaty Negotiations

Variable Name	Variable Description	Mean and Standard Deviation of Variables
RIVERGROUP1 PAIRGROUP1	1 = if all the riparian states on a river have similar GDPs per capita and similar populations (less than 2X difference) and the two countries in the country pair are also less than 2X difference 0 = otherwise	0.03 (0.16)
RIVERGROUP2 PAIRGROUP1	1 = if one of the riparian states on a river has a dominant GDP per capita (at least 2X difference) and another riparian state has a dominant (at least 2X difference) population size and the two countries in the country pair have similar GDPs per capita and similar populations 0 = otherwise	0.09 (0.29)
RIVERGROUP2 PAIRGROUP2	1 = if one of the riparian states on a river has a dominant GDP per capita and another riparian state has a dominant population size and one of the two states in a country pair has a dominant GDP per capita and the other a dominant population size 0 = otherwise	0.12 (0.32)
RIVERGROUP2 PAIRGROUP3a	1 = if one of the riparian states on a river has a dominant GDP per capita and another riparian state has a dominant population size and one of the two states in a country pair has a dominant population size but both states have a similar GDP per capita 0 = otherwise	0.15 (0.36)
RIVERGROUP2 PAIRGROUP3b	1 = if one of the riparian states on a river has a dominant GDP per capita and another riparian state has a dominant population size and one of the two states in a country pair has a dominant GDP per capita but both states have a similar population size 0 = otherwise	0.08 (0.27)
RIVERGROUP2 PAIRGROUP3c	1 = if one of the riparian states on a river has a dominant GDP per capita and another riparian state has a dominant population size and one of the two states in a country pair has a dominant GDP per capita and a dominant population size 0 = otherwise	0.10 (0.30)
RIVERGROUP3a PAIRGROUP1	1 = if one of the riparian states on a river has a dominant population size but the riparian states have similar GDPs per capita and the two countries in the country pair have similar GDPs per capita and similar populations 0 = otherwise	0.02 (0.16)
RIVERGROUP3a PAIRGROUP3a	1 = if one of the riparian states on a river has a dominant population size but the riparian states have similar GDPs per capita and one of the two states in a country pair has a dominant population size but both have a similar GDP per capita 0 = otherwise	0.19 (0.39)
RIVERGROUP3b PAIRGROUP3b	1 = if one of the riparian states on a river has a dominant GDP per capita but the riparian states have similar population sizes and one of the two states in a country pair has a dominant GDP per capita but both have a similar population size 0 = otherwise	0.02 (0.13)
RIVERGROUP3c PAIRGROUP1	1 = if one of the riparian states on a river has a dominant GDP per capita and a dominant population size but the two countries in the country pair have similar GDPs per capita and similar population sizes 0 = otherwise	0.04 (0.19)
RIVERGROUP3c PAIRGROUP2	1 = if one of the riparian states on a river has a dominant GDP per capita and a dominant population size but one of the two states in a country pair has a dominant GDP per capita and the other a dominant population size 0 = otherwise	0.01 (0.11)
RIVERGROUP3c PAIRGROUP3a	1 = if one of the riparian states on a river has a dominant GDP per capita and a dominant population size and one of the two states in a country pair has a dominant population size but both states have a similar GDP per capita 0 = otherwise	0.05 (0.23)

Table 5. (continued)

Variable Name	Variable Description	Mean and Standard Deviation of Variables
RIVERGROUP3c PAIRGROUP3b	1 = if one of the riparian states on a river has a dominant GDP per capita and a dominant population size and one of the two states in a country pair has a dominant GDP per capita but both states have a similar population size 0 = otherwise	0.02 (0.14)
RIVERGROUP3c PAIRGROUP3c	1 = if one of the riparian states on a river has a dominant GDP per capita and a dominant population size and one of the two states in a country pair has a dominant GDP per capita and population size 0 = otherwise	0.07 (0.26)
AFRICA	1 = if the river/country pair is in Africa 0 = otherwise	0.37 (0.48)
ASIA	1 = if the river/country pair is in Asia 0 = otherwise	0.16 (0.37)
EUROPE	1 = if the river/country pair is in Europe 0 = otherwise	0.33 (0.47)
N AMERICA	1 = if the river/country pair is in North America 0 = otherwise	0.02 (0.16)
S AMERICA	1 = if the river/country pair is in South America 0 = otherwise	0.11 (0.32)
WEST	1 = if the country pair is in the Western culture/civilization 0 = otherwise	0.15 (0.36)
LATIN AMER	1 = if the country pair is in the Latin American culture/civilization 0 = otherwise	0.09 (0.28)
AFRICAN	1 = if the country pair is in the African culture/civilization 0 = otherwise	0.17 (0.38)
ISLAMIC	1 = if the country pair is in the Islamic culture/civilization 0 = otherwise	0.08 (0.28)
ORTHODOX	1 = if the country pair is in the Eastern Orthodox culture/civilization 0 = otherwise	0.07 (0.26)
SINIC	1 = if the country pair is in the Sinic culture/civilization 0 = otherwise	0.01 (0.10)
BUDDHIST	1 = if the country pair is in the Buddhist culture/civilization 0 = otherwise	0.01 (0.10)
MULTIPLE	1 = if the country pair is in multiple cultures/civilizations 0 = otherwise	0.41 (0.49)
UPDOWN	1 = if the country pair is located adjacently upstream/downstream on the river 0 = otherwise	0.41 (0.49)
SIDESIDE	1 = if the country pair is located side by side on the river 0 = otherwise	0.03 (0.17)
NOTOUCH	1 = if the country pair does not touch each other on the river 0 = otherwise	0.22 (0.41)
UPSIDE	1 = if the country pair is located both upstream/downstream and side by side on the river 0 = otherwise	0.14 (0.35)
UPDOWNNT	1 = if the country pair is located upstream/downstream on the river but is not adjacent 0 = otherwise	0.20 (0.40)

civilizations are less likely to have a treaty than a river exclusively within Western (i.e., European and North American) civilization. Surprisingly, a country pair from multiple civilizations was more likely to have a treaty than a pair from the same civilization (except for the Western civilization).

[49] The results from these two sets of models lend support to both the economic gains from trade and political economy explanations of cooperative action on international rivers (hypotheses 1 and 4). In particular, group 2 rivers (and to a lesser extent group 3c rivers) are much more likely to have treaties than any of the other groups in our typology. One reason for this result may simply be that many of the world's largest and most important rivers are group 2 rivers. The fact that international rivers with multiple civilizations appear no less likely to have treaties than rivers entirely in Latin American, African, Islamic, and Eastern Orthodox civilizations runs counter to Huntington's "clash of civilizations" story (providing no support for hypothesis 3).

[50] Importantly for water resources specialists, there is likewise no support for hypothesis 2, i.e., in the country pairs models the proximity of riparian states had a negative, not a positive effect on success in negotiating a treaty. Adjacent upstream/downstream or side-by-side country pairs were less likely than country pairs with other spatial relationships to have treaties (Figures 1a–1c). Country pairs in which the two riparian states do not border each other are more likely to have a treaty than adjacent upstream/downstream states (Figures 1d–1e).

[51] The findings suggest that states with comparable economic and political power may have already achieved

Table 6. Country Pairs and Treaties by Pairing Classification

	Number of Pairs	Percent of Pairs	Number of Treaties	Percent of Treaties
Group 1: Comparable	129	18.86	136	25.47
Group 2: Countervailing	89	13.01	45	8.43
Group 3a: Population hegemon	271	39.62	190	35.58
Group 3b: Economic hegemon	77	11.26	99	18.54
Group 3c: Population/economic hegemon	118	17.25	64	11.99

a stable "balance of power," and thus are less likely to cooperate on new treaties (providing support for hypothesis 4). Both group 1 rivers (similar economic and population situations) and group 1 country pairs were much less likely to have successfully negotiated a treaty. Balance of power considerations may also partly explain our finding from the country pairs models that nonadjacent states were more likely to have a treaty. On the other hand, even if two riparians do not share a boundary, they may share water (e.g., Egypt and Ethiopia are nonadjacent, but share the waters of the Nile). Also, rivers that have two nonbordering countries are more likely to be large rivers, and one would expect large rivers to be more important to states from an economic perspective.

[52] Riparian states on international rivers in the West were much more likely to have concluded treaties than riparian states on rivers in other civilizations. There are numerous plausible explanations for this result. One is that countries in the West have a longer history of applying their legal system to problems of international rivers, and they may simply have learned how to do it. A related argument is that the West is wealthier than other civilizations, and negotiating treaties is expensive. It requires a high level of expertise that is not available in other regions. The positive

Table 7. Multivariate Models of the Determinants of Concluding Treaty Negotiations, Logistic Regression With Binary Dependent Variable (Treaty/No Treaty)

Independent Variables	Continent Model	Civilization Model	Combination Model
Intercept	−2.29[a] (0.75)	−1.49[b] (0.78)	−2.44[a] (0.76)
River group 2			
Pair group 1	2.75[a] (0.79)	3.39[a] (0.84)	2.75[a] (0.79)
Pair group 2	1.87[b] (0.78)	2.70[a] (0.83)	1.86[b] (0.78)
Pair group 3a	2.60[a] (0.77)	2.74[a] (0.81)	2.54[a] (0.77)
Pair group 3b	2.66[a] (0.80)	3.12[a] (0.85)	2.60[a] (0.80)
Pair group 3c	2.16[a] (0.79)	2.66[a] (0.83)	2.09[a] (0.79)
River group 3a			
Pair group 1	1.25 (0.93)	0.55 (0.96)	1.37 (0.93)
Pair group 3a	1.12 (0.78)	0.81 (0.80)	1.12 (0.78)
River group 3b			
Pair group 3b	−12.66 (616.3)	−12.17 (595.9)	−12.81 (609.5)
River group 3c			
Pair group 1	2.66[a] (0.85)	2.92[a] (0.89)	2.51[a] (0.86)
Pair group 2	1.19 (0.29)	1.76 (1.18)	1.21 (1.13)
Pair group 3a	2.51[a] (0.83)	2.95[a] (0.87)	2.50[a] (0.83)
Pair group 3b	2.16[b] (0.95)	2.52[b] (0.99)	1.98[b] (0.96)
Pair group 3c	1.63[b] (0.83)	1.69[b] (0.86)	1.53[c] (0.83)
Africa	−0.54[b] (0.23)		−0.56[b] (0.23)
Asia	−1.81[a] (0.33)		−2.01[a] (0.34)
South America	−0.42 (0.32)		−0.36 (0.32)
North America	−0.15 (0.62)		−0.16 (0.63)
Latin American		−1.89[a] (0.45)	
African		−2.91[a] (0.40)	
Islamic		−1.94[a] (0.44)	
Sinic		−2.70[b] (1.17)	
Orthodox		−2.33[b] (0.47)	
Buddhist		−1.90[b] (0.84)	
Multiple civilizations		−1.46[a] (0.32)	0.60[a] (0.19)
Side by side only	−0.62 (0.62)	−0.27 (0.63)	−0.71 (0.62)
Not touching, not upstream/downstream	0.88[a] (0.24)	0.98[a] (0.25)	0.80[a] (0.24)
Upstream/downstream and side by side	0.03 (0.28)	0.28 (0.29)	0.11 (0.28)
Upstream/downstream but not touching	0.67[a] (0.25)	0.54[b] (0.25)	0.55[b] (0.25)
Likelihood ratio	154.49 ($p < 0.0001$)	187.90 ($p < 0.0001$)	164.19 ($p < 0.0001$)
Percent correct prediction	76.3%	79.1%	77.5%

[a]Significant at 0.01.
[b]Significant at 0.05.
[c]Significant at 0.10.

Table 8. Largest Rivers Without Treaties

Group 2 Rivers Without Treaties	Multicivilization Rivers Without Treaties	Group 2 and Multicivilization Rivers Without Treaties
Congo/Zaire (Congo, Dem., Central African Rep., Angola, Congo, Rep., Zambia, Tanzania, Cameroon, Burundi, Rwanda, Gabon, Malawi)	Ob (Russia, Kazakhstan, China)	Juba-Shibeli (Ethiopia, Somalia, Kenya)
Juba-Shibeli (Ethiopia, Somalia, Kenya)	Yenisey (Russia, Mongolia)	Salween (China, Myanmar, Thailand)
Salween (China, Myanmar, Thailand)	Tarim (China, Kyrgyzstan, Pakistan, Tajikistan, Kazakhstan, Afghanistan)	Kura-Araks (Azerbaijan, Georgia, Iran, Armenia, Turkey, Russia)
Ogooue (Gabon, Congo, Rep., Cameroon, Equatorial Guinea)	Juba-Shibeli (Ethiopia, Somalia, Kenya)	
Kura-Araks (Azerbaijan, Georgia, Iran, Armenia, Turkey, Russia)	Volta (Burkina Faso, Ghana, Togo, Mali, Benin, Ivory Coast)	

relationship between multiple civilizations and success negotiating a treaty could be because riparian states on these rivers view the need for a cooperative agreement as more pressing and salient, even if it were more difficult to achieve.

5. Concluding Remarks

[53] There is an emerging consensus in the global development community that multilateral organizations have an important role to play in facilitating cooperative agreements among riparian states on international rivers and in financing river basin development programs [*Waterbury and Whittington*, 1998; *Sadoff et al.*, 2002; *Waterbury*, 2002]. While our findings provide no evidence one way or the other on the validity of this proposition, they may provide multilateral organizations some insights into how best to proceed in this policy arena. From the perspective of multilateral organizations, engagement with riparian states on international rivers is expensive, time consuming, difficult, and risky. At the present time multilateral organizations have limited political and administrative resources to assist riparian states with the challenges of cooperative development of international rivers, and thus must select carefully the international rivers on which they become engaged.

[54] Broadly speaking, multilateral organizations must choose between two main approaches for selecting international rivers on which they decide to work. The first is to select the "low hanging fruit," i.e., the rivers on which success seems most likely and a modest amount of effort will yield relatively quick, significant returns. The second is to work on the most difficult, conflict-ridden rivers because these are the places where the potential returns are the greatest and because these are the rivers that are most in need of multilateral assistance (i.e., the riparian states themselves are not likely to reach agreements without international assistance). The finding that river type appears more important in determining success negotiating a treaty than country pair type is significant for multilateral organizations because it suggests that it may be possible to generate cooperative agreements on rivers where the riparian states do not have a cooperative history.

[55] The typology presented in this paper may prove useful for a preliminary screening of international rivers to identify those that one might expect would already have treaties but for some reason do not. These may prove to be those "low hanging fruit" cases. For example, our analysis suggests that group 2 rivers that do not yet have treaties may possess comparative advantages in working out treaty solutions. Similarly, one might speculate that it would be no more difficult to assist riparian states on international rivers that cross civilizations than other rivers, and the returns might be greater. Also, water resource professionals at international agencies may have a comparative advantage in facilitating agreements on rivers that cross multiple civilizations.

[56] Table 8 presents the five largest group 2 and multicivilization international rivers that do not yet have any cooperative agreements. Most of these rivers are in Africa: the Congo/Zaire, Juba-Shibeli, Ogooue and Volta. The rest are in Asia (Salween, Ob, Yenisey, Tarim) or Eastern Europe/Middle East (Kura-Araks). Interestingly four of these have riparians from the former Soviet Union. Riparians on the other rivers achieved independence relatively recently. If these areas are not "institutionally mature," it could suggest that there is a role for multilateral agencies to speed up the process by improving technical, engineering, and legal capacity.

[57] If multilateral organizations were to select international rivers on which to become engaged based on a "low hanging fruit" strategy, our analysis would suggest that the Juba-Shibeli, Salween and Kura-Araks rivers may be of particular interest because they are group 2 rivers that cross a civilization boundary, and do not yet have any treaties. Of course, this typology could only be used for a very preliminary screening; more in-depth analysis would be required. For example, a river like the Congo/Zaire may not have a treaty because water is so plentiful. It is important to emphasize, however, that our analysis does not suggest whether policy intervention by multilateral organizations will actually work. Nor do our results have anything to say about the relative efficacy of different types of policy interventions by multilateral organizations.

Appendix A: Results From the Application of the Typology—A Global Overview

[58] Our typology allows us to compare international rivers and country pairs from a global perspective and illustrates some striking similarities (and differences) between international rivers in different parts of the world. For example, Figures A1 and A2 illustrate the application of the first level of this typology (i.e., groups 1–3) to 12 large international rivers from different regions of the world. The more dispersed the positions of each country on the graph, the greater the political versus economic asymmetry. It is clear from a simple visual examination of Figures A1 and A2 that international rivers have quite different economic and population asymmetries. A quick review of Figures A1 and A2 also shows that there is often a countervailing population

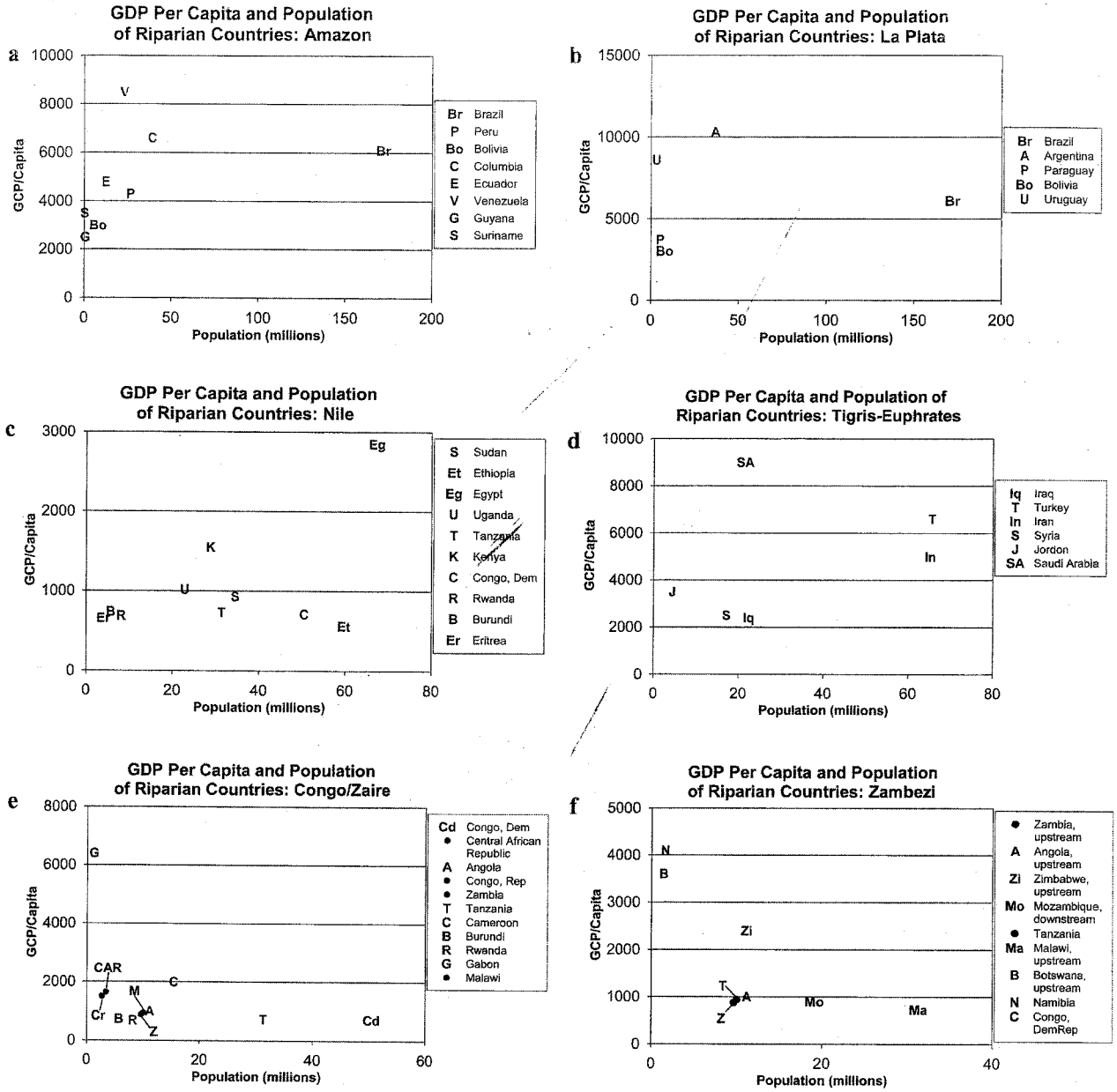

Figure A1. GDP per capita and population of riparian countries: (a) Amazon, (b) La Plata, (c) Nile, (d) Tigris-Euphrates, (e) Congo/Zaire, and (f) Zambezi.

hegemon and economic hegemon (group 2) on these large international rivers (e.g., La Plata, Amazon, Congo and the Mekong).

[59] Table A1 presents a continent-by-continent comparison of international rivers in terms of our typology. By far the most common situation is an international river with one country that is dominant in terms of population size and all the riparian states having comparable GDPs per capita (group 3a). Almost half of the world's international rivers fall into this category (136 out of 280). For international rivers shared by only two countries, the proportion of group 3a rivers is even higher; 53% of two-country rivers fall into this category. Within group 3a rivers, the dominant population hegemon is relatively evenly split between being the upstream or downstream country. Group 2 rivers (countervailing power) and group 3c rivers (with a "super" hegemon) are also common. In total 48 international rivers exhibit countervailing power situations (group 2), and 48 international rivers have one riparian country with both a dominant population and a dominant economic situation (group 3c). Rivers with "super" hegemons (group 3a) are more common in two-country rivers, while countervailing power situations are more common in international rivers with three or more riparian countries. Group 1 rivers (comparable population and economic situations) are the least common (there are no group 1 rivers with three or more riparian states). There are also few group 3b rivers (dominant economic situations but comparable populations). There are only two group 3b rivers with three or more riparian countries (the Komoe and the Drin).

[60] When we restrict our data set to the world's 200 largest rivers, and then eliminate country pairs in which

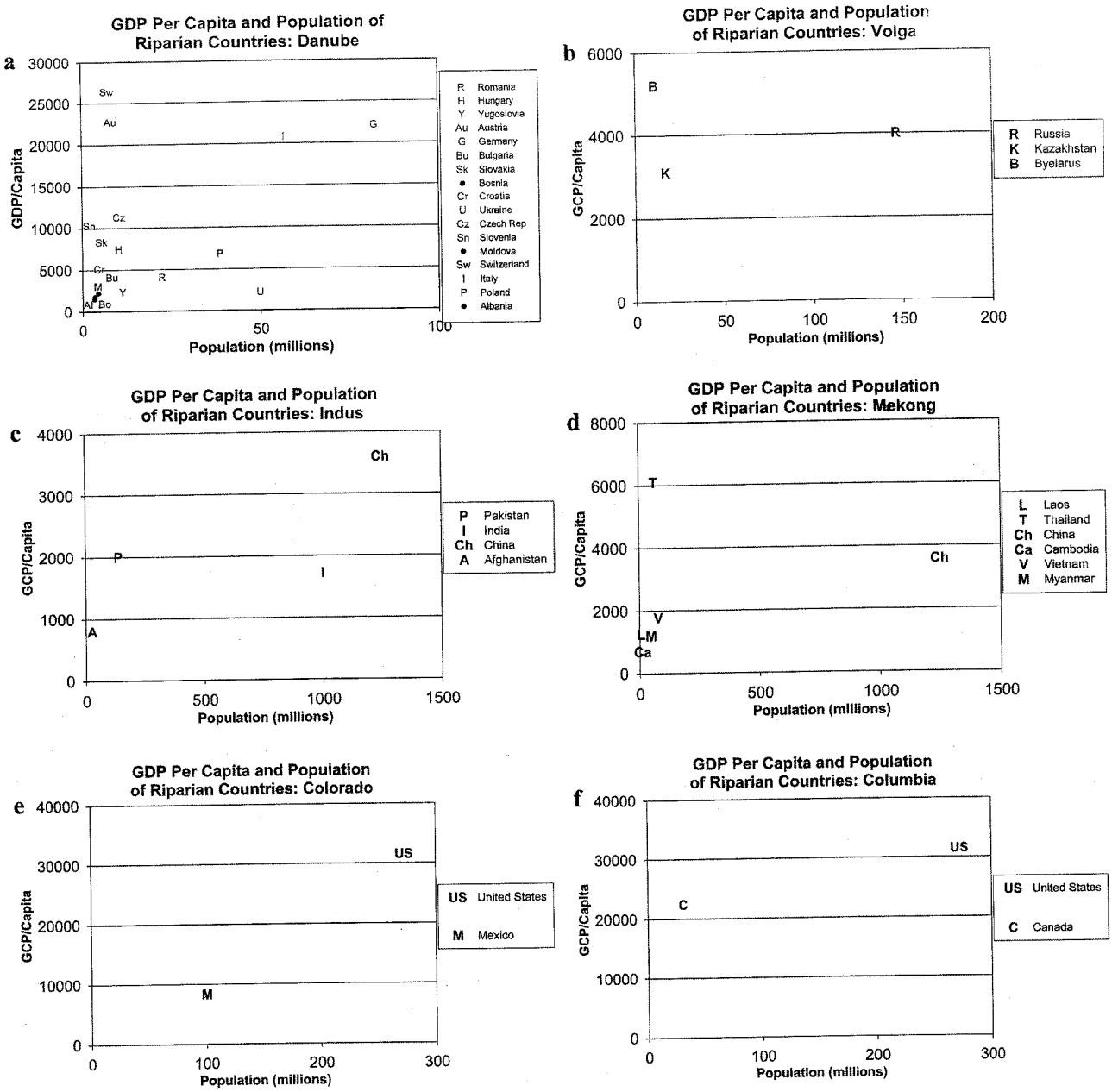

Figure A2. GDP per capita and population of riparian countries: (a) Danube, (b) Volga, (c) Indus, (d) Mekong, (e) Colorado, and (f) Columbia.

the two countries accounted for less than 1% of the river basin, we are left with 685 "significant" country pairs. This screening criterion eliminated 150 country pairs. Note that some pairs occur more than once on different rivers. For example, Argentina and Chile form country pairs on 11 different rivers. Table A2 details how these 685 country pairs are divided geographically. As is the case with the rivers typology, the most common situation in country pairs is group 3a, a dominant population riparian but similar economic situations. Unlike the situation with rivers, however, country pairs are much more evenly distributed across the groups in our typology.

[61] Although group 3a accounts for 40% of our country pairs (272 pairs), the other categories are all well represented. Interestingly, group 1 (similar economic and population situations), the least common situation in our river typology, is the second most common situation among country pairs (with 129 pairs, almost 20% of the total). This is because on international rivers with more than two riparians there tends to be a larger distinction between economic and population situations, but any two countries on the river are more likely to have similar situations. As in the river typology, country pairs are often classified as group 3c (118 country pairs fall into this classification, accounting for 17% of all country pairs). Group 2, countervailing powers, and group 3b (one riparian is dominant economically, but the two states have similar population sizes) are the least common classifications. However, both account for more than 10% of the country pairs, with 89 group 2 pairs and 77 group 3b pairs.

Table A1. Continent-by-Continent Comparison

Continent	Rivers With Two Countries					Rivers With Three or More Countries					Total
	Comparable Situations	Countervailing Power	Dominant Population Size	Dominant Economic Situation	Dominant Population Size and Economy	Comparable Situations	Countervailing Power	Dominant Population Size	Dominant Economic Situation	Dominant Population Size and Economy	
Africa	9 (14.29) (31.03)	6 (9.52) (37.50)	10 (15.87) (9.62)	7 (11.11) (41.18)	3 (4.76) (9.68)	1 (1.59) (100.00)	9 (14.29) (29.03)	8 (12.70) (25.00)	1 (1.59) (50.00)	9 (14.29) (52.94)	63
Latin America and the Caribbean	10 (17.54) (34.48)	0 (0.00) (0.00)	29 (50.88) (27.88)	5 (8.77) (29.41)	6 (10.53) (19.35)	0 (0.00) (0.00)	4 (7.02) (12.90)	2 (3.51) (6.25)	0 (0.00) (0.00)	1 (1.75) (5.88)	57
North America	0 (0.00) (0.00)	0 (0.00) (0.00)	16 (80.00) (15.38)	0 (0.00) (0.00)	4 (20.00) (12.90)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	20
Europe	10 (12.99) (34.48)	6 (7.79) (37.50)	28 (36.36) (26.92)	2 (2.60) (11.76)	3 (3.90) (9.68)	0 (0.00) (0.00)	10 (12.99) (32.26)	16 (20.78) (50.00)	1 (1.30) (50.00)	1 (1.30) (5.88)	77
Asia	0 (0.00) (0.00)	4 (6.35) (25.00)	21 (33.33) (20.19)	3 (4.76) (17.65)	15 (23.81) (48.39)	0 (0.00) (0.00)	8 (12.70) (25.81)	6 (9.52) (18.75)	0 (0.00) (0.00)	6 (9.52) (35.29)	63
Total	29	16	104	17	31	1	31	32	2	17	280

[62] Our typology reveals that the international rivers in Africa, Asia (South Asia, Southeast Asia and the Near East) and Europe share much in common; while those in North America, Latin America and the Caribbean, and East Asia appear similar to each other. Africa, Southeast Asia, and Europe have far more geopolitically complex international river situations than their counterparts in North America, Latin America and the Caribbean, and East Asia. There are far more international rivers shared by three or more countries in Europe, Asia (South Asia, Southeast Asia and the Near East), and Africa than in North America, Latin America and the Caribbean, and East Asia. The main reason is country size. North America, South America, and East Asia all have relatively large countries that have been able to reduce their international river problems by subsuming all or most of the largest rivers within their boundaries: the Yangtze and Yellow Rivers in China, the Mississippi-Missouri-Ohio river basin in the United States, the Amazon in Brazil and the Volga in Russia. The large size of neighboring countries in these regions also leads to fewer countries on international rivers.

[63] An examination of the classification of country pairs in Table A2 also highlights the differences between continents. As in the rivers typology, Africa and Europe have a similarly complex geohydrological situation when it comes to country pairs. Likewise, North America and Latin America and the Caribbean appear similar. If Asia is split into East Asia and Southeast Asia, South Asia, and the Near East, then East Asia appears more like North America and Latin America while the rest of Asia appears more similar to Europe and Africa.

[64] Country pairs in Europe and Africa are fairly well distributed between all classifications, with all containing at least 10% of the continent's country pairs (except for group 3c in Africa which is 9.9% of Africa's total country pairs). Further highlighting the geocomplexity of these two continents, Africa and Europe combine to account for at least 50%, and sometimes significantly more, of the country pairs in each category. They account for more than 80% of the group 1 and group 2 classifications, and nearly 90% of the group 3b classifications. Individually they account for at least 20% of the country pairs in each group. Approximately 80% of the country pairs in Asia, Latin American and the Caribbean, and North America are group 3a (dominant population) or group 3c (dominant population and economy).

[65] Our typology also reveals several interesting country-by-country comparisons. First, a number of country pairs can be found in which two countries with similar population sizes and economic situations share a number of rivers with each other and with no other countries. These include Morocco-Algeria (share four rivers), Ghana-Cote D'Ivoire (share two rivers), Panama-Costa Rica (share three rivers), Honduras-Nicaragua (share three rivers), Venezuela-Columbia (share two rivers), Latvia-Lithuania (share three rivers), and Latvia-Estonia (share three rivers). Second, there are a number of country pairs where two countries with countervailing population sizes and economic situations share a number of rivers with each other and with no other countries. These include Russia-Finland (share four rivers), Cameroon-Nigeria (share two rivers), Angola-Namibia (share two rivers), and Pakistan-Iran (share two rivers). A third set of

Table A2. Country Pairings: Continent-by-Continent Comparison

Continent	Group 1 Comparable Situations	Group 2 Countervailing Power	Group3a Dominant Population Size	Group 3b Dominant Economic Situation	Group3c Dominant Population Size and Economy	Total
Africa	71	49	70	38	25	253
	(28.06)	(19.37)	(27.67)	(15.02)	(9.88)	
	(55.04)	(55.06)	(25.74)	(49.35)	(21.19)	
Latin America and the Caribbean	13	1	42	5	18	79
	(16.46)	(1.27)	(53.16)	(6.33)	(22.78)	
	(10.08)	(1.12)	(15.44)	(6.49)	(15.25)	
North America	0	0	13	0	4	17
	(0.00)	(0.00)	(76.47)	(0.00)	(23.53)	
	(0.00)	(0.00)	(4.78)	(0.00)	(3.39)	
Europe	38	28	85	30	43	224
	(16.96)	(12.50)	(37.95)	(13.39)	(19.20)	
	(29.46)	(31.46)	(31.25)	(38.96)	(36.44)	
Asia	7	11	62	4	28	112
	(6.25)	(9.82)	(55.36)	(3.57)	(25.00)	
	(5.43)	(12.36)	(22.79)	(5.19)	(23.73)	
Total	129	89	272	77	118	685

country pairs involves two large countries that share numerous rivers and where one of the countries dominates in population size, but where the two countries have similar economic situations. The most notable are China-Russia (six rivers), United States-Canada (16 rivers) and Chile-Argentina (16 rivers). In these country pairs the dominant riparian is the upstream country on some rivers and the downstream country on others.

[66] Russia is involved in more international rivers than any other country, and it finds itself in a wide variety of power situations: countervailing power structures, dominant population size but similar economic situations where it is both the dominant country on some rivers and the dominated country on others, and rivers where it is superdominant. group 2 rivers include the Amur and Tumen, group 3a rivers (which Russia dominates) include the Oral and the Yenisey, group 3a rivers (on which Russia is dominated) include the Ob and Pu-Lun-To, and group 3c rivers (on which Russia is superdominant) include the Samur.

[67] Vietnam and Mexico are similar in an unusual way. On some rivers they are superdominant and on others they are superdominated. Vietnam is superdominant on rivers it shares with Cambodia (the Saigon and Song Vam Co Dong), but it is superdominated on rivers it shares with China (the Hsi/Bei, Beilun, Zuo/Xi and Red/Song Hong). Mexico likewise is superdominant on the rivers it shares with Guatemala (the Coatan Achute, Candelaria, Grijalva, Suchiate and Hondo), but it is superdominated on the rivers it shares with the United States (the Colorado, Rio Grande, Yaqui and Tijuana).

[68] A number of country pairs can be found where two countries share a number of rivers and one country is always superdominant (these include Iran-Azerbaijan (share two rivers), Turkey-Syria (share two rivers), Venezuela-Guyana (share two rivers), Gabon-Equatorial Guinea (share three rivers). Other superdominant pairs include South Korea-North Korea, Turkey-Georgia, Pakistan-Afghanistan, Iran-Afghanistan, Iran-Turkmenistan, Russia-Azerbaijan, Greece-Albania and Italy-Slovenia). Relatively less common are situations in which one country is superdominant on a river shared among three or more countries. This makes the situation of South Africa quite striking. South Africa is superdominant on five rivers involving three or more countries (the Limpopo, Maputo, Incomati, Umbeluzi, and Orange).

[69] Complicating the dynamics of treaty negotiations, 77 country pairs share 3 or more international rivers; in total these 77 country pairs account for 40% (283 pairs) of the major 685 country pairs on the 200 largest international rivers. Table A3 shows the 30 country pairs that share four

Table A3. Country Pairs Sharing Four or More International Rivers by Continent

Continent	Country Pairs	Number of Pairs	Classification
Africa	Algeria-Morocco	4	group 1
Africa	Angola-Namibia	4	group 2
Africa	Equatorial Guinea-Gabon	5	group 3c
Africa	Ghana-Ivory Coast	4	group 1
Africa	Guinea-Ivory Coast	5	group 3a
Africa	Guinea-Liberia	6	group 3a
Africa	Guinea-Sierra Leone	4	group 3b
Africa	Mozambique-South Africa	4	group 3c
Africa	Mozambique-Zimbabwe	4	group 3b
Asia	China-Kazakhstan	4	group 3a
Asia	China-Myanmar	4	group 3a
Asia	China-Russia	6	group 3a
Asia	Indonesia-Papua New Guinea	4	group 3a
Asia	Kazakhstan-Russia	4	group 3a
Asia	Laos-Vietnam	4	group 3a
Asia	Mongolia-Russia	4	group 3a
Europe	Byelarus-Russia	5	group 3a
Europe	Czech Rep-Poland	4	group 3a
Europe	Czech Rep-Slovakia	4	group 1
Europe	Estonia-Latvia	4	group 1
Europe	Finland-Norway	4	group 1
Europe	Finland-Russia	6	group 2
Europe	Italy-Switzerland	4	group 3a
Europe	Latvia-Lithuania	4	group 1
Europe	Poland-Slovakia	4	group 3a
Europe	Portugal-Spain	4	group 3a
Latin America	Argentina-Chile	11	group 3a
Latin America	Guyana-Venezuela	4	group 3c
North America	Canada-United States	13	group 3a
North America	Mexico-United States	4	group 3c

or more international rivers: in total these 30 country pairs account for 20% (145 pairs) of the total. This means that many countries must consider a wider set of possible issues than they would if they shared only one river.

[70] The situation is even more complicated for countries like China and Russia that share multiple rivers with multiple countries. China shares three or more rivers with countries in seven different country pairs (India, Kazakhstan, North Korea, Mongolia, Myanmar, Russia, and Vietnam). Russia likewise shares three or more rivers with countries in nine different country pairs (Azerbaijan, Byelarus, China, Finland, Georgia, Kazakhstan, Latvia, Mongolia, and Ukraine). As can be seen by the list of country pairs in which Russia is a party, the complexity of its water situation has increased significantly with the breakup of the Soviet Union.

[71] The complexity of the international river situation in Africa is also worth emphasizing. Of the 77 country pairs that share three or more rivers, 25 are in Africa. These country pairs also have the widest variation in our typology classification. For example, Guinea is involved in multiple country pairs with the Ivory Coast, Liberia, Senegal and Sierra Leone. The Ivory Coast has multiple country pairs with Guinea, Liberia, Burkina Faso, Ghana and Mali. Similarly, Mozambique is involved in multiple country pairs with South Africa, Swaziland and Zimbabwe. South Africa also shares multiple country pairs with Swaziland, and Zimbabwe shares multiple country pairs with Botswana. A number of other country pairs occur repeatedly, including Equatorial Guinea/Gabon on five separate international rivers. Africa's complicated geographical situation, created in part by small countries and numerous meandering rivers, probably makes the possibility of formulating single issue, bilateral agreements both more difficult and less valuable.

[72] The implications to a country of sharing multiple rivers with multiple riparian states warrant further study. Simple negotiating strategies based on acquired rights, appreciable harm, and unlimited territorial sovereignty do not work well for countries like Russia that are involved in numerous rivers, or for countries like Mexico that are both dominant and dominated. Particularly when countries share international rivers of different types or have different geographical relationships, other riparian states will pay attention to a country's negotiating history as a means of securing an advantage in their own negotiations. For a state acting strategically, the potential effect on future negotiations will be an ever present element influencing current negotiations on a particular river. The state that treats each negotiation in isolation risks losing credibility in the future.

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