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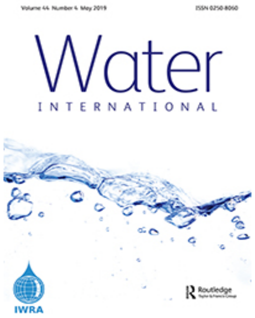

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RESEARCH ARTICLE

Why are there so few basin-wide treaties? Economics and politics of coalition formation in multilateral international river basins

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ABSTRACT

Examinations of international water treaties suggest that riparian states are not heeding the advice to adopt IWRM. Theories suggest that the larger the number of negotiating states, the lower the cost (per state) of the joint operation of treaties, but the higher the transaction costs of negotiating and maintaining them. We model the trade-off between benefits and costs associated with the number of treaty signatories and apply it to a global treaty data-set. Findings confirm that the transaction costs of negotiation and the economies of scale are important in determining the paucity of basin-wide agreements, the treaties' content and their extent.

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International water; transaction cost; economies of scale; water treaties; cooperation

Introduction

Interest in international cooperation has gained momentum recently with the increase in both the rate of signing and the analysis of international environmental agreements (IEAs) on energy, pollution, nature, oceans, species, weapons' impact on the environment, and freshwater (International Environmental Agreements Database Project, n.d.). Interest in analyzing international freshwater agreements has also increased because of the decreasing water availability in basins shared by riparian states (e.g., Jordan, Ganges). And the increasing demand for water brought about by population growth and industrialization has raised the potential for riparian conflict and tension (Dinar & Dinar, 2017).

Recent work in the international relations field, examining international freshwater agreements (Brochmann, 2012; Dinar, Katz, De Stefano, & Blankespoor, 2015; Mitchell & Zawahri, 2015; Tir & Stinnett, 2012; Zentner, 2010), combines different event-based databases (International Water Event Database; Issue Correlates of War – River Claims Data Set; Rivers Cooperation and Conflict Database) that trace water disputes between riparians with databases covering the content of water treaties to examine the effectiveness of treaty design in managing transboundary water disputes. The findings reveal that treaties

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can contribute to acceptable and effective management of transboundary rivers (in this article we do not address transboundary aquifers), but effectiveness appears to depend on the specific design features of the treaties.

Research focusing on international water agreements covering multilateral basins also suggests that treaties that include all the riparian states (basin-wide treaties, such as the 1967 La Plata agreement) are exceptionally rare, existing in only 13% of the world's multilateral basins (Giordano et al., 2013). This finding contradicts the international agencies, environmentalists and engineers who encourage states to negotiate and reach basin-wide agreements to develop the basin in an efficient manner. With the exception of qualitative case studies (Kempkey, Pinard, Pochat, & Dinar, 2009; Waterbury, 2002), there is little systematic empirical analysis of the factors influencing the formation and design of basin-wide accords. Consequently, we are unable to provide policy advice to mediators attempting to promote the formation of basin-wide accords.

This article seeks to fill this gap in the literature by attempting to explain the factors accounting for the relatively low number of basin-wide agreements in multilateral basins and for the content of these agreements. Combining theories of international relations and economics, we consider the influence of two factors. The first is the transaction costs of negotiating, enforcing and monitoring treaty commitments among a larger number of signatory riparian states. The second is economies of scale: the benefit of having a large group of states involved in the treaty, which could lower the average cost of the joint activity for each state. We examine the impact of these two factors not only on treaty formation but also on treaty contents, looking at the specific topics and problems addressed in water treaties (or issue areas) and the institutional features. Treaties governing international basins can cover various issues, such as allocating the river's waters, environmental regulation, hydropower generation, groundwater regulation, navigation, fishing, irrigation and infrastructure development. River treaties can also include institutional mechanisms for implementing the treaty and maintaining future cooperation. We examine the influence of economies of scale and transaction costs in the basin-wide contest on the degree of institutionalization, or the number of institutional mechanisms included in the treaty, such as information exchange, monitoring, conflict resolution, enforcement, joint management and river basin organizations. The influences of several control variables are considered, including power asymmetry, welfare power, regime type, type of domestic legal systems, and international environmental non-governmental organizations. This helps move the discussion from the nature of the involved states (as in the present literature) to the nature of the interaction among the states, which is a much more comprehensive concept that allows us to understand the scope and stability of the agreement.

This work addresses all the basins in the world, of all shapes and sizes, rather than examples restricted to three or four riparian states and one type of basin geography. This study is conclusive because it addresses all the aforementioned potential issues facing basin riparians and not only the water sharing problem. By combining economics and politics into one analysis, by controlling for geography and size, and by including many disputed topics in all basins, this analysis provides robust answers to the understanding of basin-wide cooperation. Adding the economies of scale and transaction cost variables to the models allows us move the discussion from the characteristics of the involved states to the nature of the interaction among the states. This, in our opinion, is a major contribution to the literature.

We find that power asymmetry in the basin is negatively correlated with basin-wide treaties. That is, the presence of a basin-hegemon, such as India along the Ganges or China along the Mekong, reduces the likelihood of a basin-wide agreement among the riparian states. However, democratic dyads and welfare power in the basin increase the probability of reaching basin-wide agreements. As for treaty content, the transaction cost of negotiating in a basin-wide context increases the likelihood of treaties that cover environmental regulation and/or water allocation. However, the greater economies of scale associated with basin-wide agreements (as the number of riparians negotiating increases) reduce the likelihood of treaties that include these two topics. Furthermore, the higher transaction costs of negotiating and implementing basin-wide agreements tend to reduce the number of issue areas included in the agreement, while economies of scale could increase the number of issue areas included in the basin-wide treaties. Empirical analysis also reveals that the higher transaction cost and greater economies of scale associated with basin-wide negotiations positively influences the number of institutional mechanisms incorporated in a treaty.

The article is structured as follows. The next section considers lessons from previous work. The third section presents a stylized model for the analysis, from which we derive general hypotheses. The fourth describes the data-sets we use and the control variables we constructed. The fifth provides details on the empirical models used in the estimation process, while the sixth presents the results of the models and their interpretation. We conclude with policy implications that can provide guidance for the future of international water treaties in light of continued increase in water scarcity.

Previous work on international water agreements

Combining theories of international relations and economics, and based on the literature examining IEAs, we seek a better understanding of the complexity of collaboration as the number of participating states increases. The problem confronting states attempting to cooperate can be divided into the bargaining phase leading up to treaty signing, and enforcement of treaty commitments (Fearon, 1998). The number of negotiating states can complicate both phases (Olson, 1965; Oye, 1985). The diversity of interests among states and the difficulty of identifying and punishing non-complying states results in higher transaction costs to reach and maintain multilateral cooperation. To reduce the transaction costs of monitoring and enforcement problems associated with multilateral interactions, states invest in institutional capabilities (Keohane, 1986; Martin, 1992; Verdier, 2008). Institutions can provide member states with valuable information, along with reducing the transaction costs of future cooperation (Keohane, 1986). Alternatively, to account for the variance in multilateral, minilateral and bilateral institution structure, Katzenstein (1997) suggests considering the interests of the powerful state, norms, and domestic state structure. Powerful states may impose their preferences on the institutional structure and use their authority to lower the transaction cost of negotiation and maintaining cooperation (Katzenstein, 1997; Cohen, 1997; Zawahri & Mitchell, 2011; Zeitoun & Warner, 2006). Neoliberal international relations theories argue that the degree of institutionalization should increase as the number of collaborators increases. Greater institutionalization reduces transaction costs and enforcement problems associated with multilateral interactions (Drezner, 2000; Verdier, 2008). A review and comparative analysis of treaty mechanisms to deal with flow variability in shared basins can be found in Drieschova, Giordano, and Fischhendler (2008).

The literature analyzing IEAs considers treaties covering CO_2 emission and ozone regulation, along with other international agreements (Barrett, 1994; Carraro, 1997, 2003; Chander & Tulkens, 1997, 2006; Delfino, Caputo, & Zhu, 2015; Finus, 2003, 2008; Gengenbach, Weikard, & Ensink, 2010). It considers questions about how many and which states will join a treaty, and whether there will be one treaty or multiple co-existing treaties. This literature tends to focus on the presumed stability of global treaties and on finding arrangements that prevent free-riding, which can undermine cooperation among signatory parties and disincentivize new members to join the grand coalition. Empirical analysis of IEAs suggests that the ability to sign certain treaties changes as the number of negotiating states increases (Barrett, 1994; Gengenbach et al., 2010; Just & Netanyahu, 1998).

The case of international waters differs from that of global pollution regulation in that it includes a much smaller set of players and much more evident negative externality effects among the basin riparians. Another important difference is that many of the IEAs regulate global public goods, while many aspects covered in international water treaties address common pool resources such as shared water and joint water projects. These differences necessitate some caution in applying the approaches and findings from the literature that assesses global IEAs' size and stability to multilateral river basin negotiations and treaties.

Despite these cautions, we can still learn from the findings of the literature on global IEAs, because several drivers intervene in the negotiation and enforcement of both global pollution agreements and international water treaties. First, the economies of scale of the joint investment, and the operational and maintenance cost of joint facilities associated with the number of participants (states), are important elements of the development of any international agreement. Second, there are diseconomies of scale (depending also on the nature of treaties) associated with the transaction cost of negotiating and managing the agreement, because distributional and enforcement problems become much more destructive as the number of negotiating states grows (Chander & Tulkens, 2006; Just & Netanyahu, 1998).

Several studies have sought to examine the rise and content of basin-wide agreements. Drawing on game theory, Houba, van Der Lan, and Zeng (2015) and Ansink, Gengenbach, and Weikard (2017) focused on coalition formation in international river basins *vis-à-vis* water allocation. Both studies found that a grand coalition may not be economically attractive to the riparian states. However, the two analyses used three riparians (Houba et al., 2015) and four riparians (Ansink et al., 2017) through a given geography of the river basin, and symmetry of all riparians *vis-à-vis* economic and social capacity. Consequently, it is difficult to draw conclusions for basins with more riparians or different basin geographies. While not considering the formation of basin-wide agreements, Zawahri and Mitchell (2011) considered the factors influencing the formation of bilateral and multilateral accords on bilateral and multilateral basins. They discovered that fragmented governance of multilateral basins is a result of the transaction costs associated with negotiating these treaties, the distribution of power within the basin, and state interest (Zawahri & Mitchell, 2011).

Through empirical analysis of several databases, Zawahri, Dinar, and Nigatu (2014) analyzed the impact of the challenges confronting bilateral and multilateral negotiations on treaty content. While the multilateral and basin-wide negotiation context can result in treaties focusing on environmental regulation, when these researchers empirically examined the impact of an increase in the number of riparians, they discovered that there is a lower likelihood of reaching basin-wide treaties covering environmental regulation. This is in line with the conclusions of Barrett (1994), Just and Netanyahu (1998), and Finus (2008), who argue that treaty content (the issues covered by the treaty) is affected by the number of negotiating states. Greater numbers of negotiating and signatory states reduce the possibility of reaching treaties covering water quantity (Zawahri et al., 2014). These findings suggest that the transaction costs of negotiating and maintaining cooperation in a multilateral context increase and impact treaty content.

The emerging literature on measuring the number of cooperative and conflictive events in international river basins (e.g., De Stefano, Edwards, de Silva, & Wolf, 2010; Kalbhenn & Bernauer, 2012; Yoffe, Wolf, & Giordano, 2003) is based on the premise that the likelihood and intensity of conflict within a basin increases as the physical or institutional change needed to address the conflict exceeds the capacity in the basin to internalize that change. The data in this literature capture this gap in terms of the number of conflictive/cooperative events. We use the number of events as a proxy for transaction costs because the higher the level of conflict in the past, the harder it will be to overcome resistance to reach an agreement.

Another important conclusion from theoretical and empirical work on large-*N* treaties (Barrett, 1994; Just & Netanyahu, 1998; Zawahri et al., 2014) is that basins with a large number of riparian states face high transaction costs for treaty development, which makes building basin-wide institutions hard. Even if a treaty is formed under such situation, its stability is at risk (Barrett, 1994, 1998; Zawahri et al., 2014).

As for specific examples from river basins that were analyzed in the literature for the likelihood of basin-wide coalitions, Gilman, Pochat, and Dinar (2008) observed that in the La Plata, a five-riparian basin, of the 16 treaties signed between 1946 and 2007, only three were basin-wide. They suggest that basin-wide treaties are more likely in the La Plata when general topics are negotiated. Using variables such as asymmetry of information, scientific capacity, economic power and other state characteristics among basin riparians, the transaction cost of treaty enforcement and sovereignty over water is addressed vaguely, mainly in specifying declarations of intent. Sub-basin treaties were more likely in areas where the grand coalitions can be derailed by economic inefficiencies and high transaction costs, such as the monitoring and enforcement needed to track pollution and excess groundwater pumping. However, Gilman et al. (2008) suggest that partial coalitions may create the basis for and lead to the creation of the basin-wide agreements in the long run.

In a comparative study of the negotiation process of the treaties reached (or not) in four international through-border basins – La Plata (five riparians), Mekong (six riparians), Nile (now 11 riparians) and Aral Sea (five riparians) – Kempkey et al. (2009) suggest that the combination of the number of riparians and the variation in the number and complexity of issue areas negotiated explains the partial coalitions in each of the basins.[1] One of the reasons they suggest for reaching sub-basin treaties is that states negotiated development projects rather than squabbling over water allocation rules. By focusing on development projects that could mitigate the relative water scarcity problems, riparian states were able to find common ground for agreement.

A stylized model

We model possible basin cooperation, extending and simplifying the works of Just and Netanyahu (1998) and Chander and Tulkens (2006). A major difference between these two studies is that they refer to different coalition sizes. However, their research questions are similar and serve as a departure point for our model. Our model considers coalitional efforts as being affected by the transaction costs of the negotiation and the implementation of the treaty; on the other hand, cooperation level is affected by the economies of scale. In other words, we observe two opposing factors: benefits from having a larger group of agents involved, which lowers the average cost of the joint activity for individual states; and the transaction costs of enforcement and monitoring, which grow with the number of states involved in the agreement.

We start with a very simple model of costs and benefits associated with cooperation among a group of agents. Assume a basin with N_1 riparian states. Cooperation in the basin is reflected in an agreement among all or some of the riparians on managing the basin resources. The number of signatories is N_2, which is less than or equal to N_1. The riparian states in the basin can negotiate over the joint management of the basin resources, such as allocation of water, management of environment, development of economic activities, building joint institutions to manage the basin, etc. For simplicity and without loss of generality, we use several simplifying assumptions.

We assume in the theoretical model that only one issue is considered for an agreement among the basin riparian states. We assume homogeneity across states, so that the benefit and cost functions are the same for each riparian state. We also assume that states can be engaged in only one agreement. Therefore, we cannot see the negotiation of multiple agreements for a state by sub-coalitions in the basin at the same point in time. And finally, we assume that each riparian state is motivated only by the incremental gains from joining a given agreement, ignoring any strategic behaviour associated with power and hegemony in the basin. Since the stylized model includes only effects of the economies of scale and transaction costs, and no strategic or political aspects, we introduce these needed simplifying assumptions. These assumptions will be relaxed and adjusted to the international water treaty data-set to allow our empirical analysis.

Departing from Just and Netanyahu (1998), we define a payoff function for each group (coalition) of riparian states (players/agents) that decides to sign an agreement (cooperate). The payoff function has two elements: the benefits function and the transaction cost function. The payoff to the coalition is the difference between the benefits and the transaction cost. The benefits function is monotonically increasing, and the transaction cost is exponentially increasing with the number of players, n ($n \leq N_2 \leq N_1$), who are members of the coalition.[2] We assume well-behaved, continuous, twice differentiable benefit and transaction cost functions.

Mathematically, let $B = b(n)$ be the benefits from the agreement, with $\frac{db}{dn} \geq 0$ and $\frac{d^2b}{dn^2} \leq 0$, and $C = c(n)$ be the transaction costs associated with the agreement, with $\frac{dc}{dn} \geq 0$ and $\frac{d^2c}{dn^2} \geq 0$. Then the payoff to the group from cooperation is $\pi(n) = b(n) - c(n)$.

As we are interested in exploring the impact of the number of basin riparians on the incentives to cooperate (sign a treaty) at the basin level, we derive the first-order conditions for $\pi(n)$ and explore the conditions for maximization in terms of the number of riparians that participate in the agreement. We equate the first derivative of $\pi(n)$, with respect to n, to 0 to obtain $\frac{d\pi(n)}{dn} = \frac{db(n)}{dn} - \frac{dc(n)}{dn} = 0 \Rightarrow \frac{db(n)}{dn} = \frac{dc(n)}{dn}$. Given that $\frac{db(n)}{dn}(N_1)lt;\frac{dc(n)}{dn}(N_1)$ means that under the assumed behaviour of the benefit function and the transaction cost function,[3] and given the assumed stylized objectives of the players, the resulting number of players signing a treaty that maximizes $\pi(n)$ is $N_2 = n^*$, where $1 \le n^* \le N_1$. Note that $n = 0$ is used only for purposes of describing the continuity of the range of number of players in the coalition but has no meaning as a size of a coalition (Figure 1).

At this stage we attempt to derive several general hypotheses from the simple model. We identify several illustrative cases that are characterized by the degree of concavity of the benefit function, $b(n)$, as the number of players increases, on the one hand, and by the degree of the curvature of the transaction cost function, $c(n)$, as the number of players increases. The curvature of the benefit and transaction cost functions reflects the nature of the physical conditions in the basin and the issues negotiated in the treaty, all of which affect the desire of the players to join the grand coalition, and impact the stability of the (basin-wide) grand coalition in the case that it forms (Just & Netanyahu, 1998).

Three cases that differ in the levels of monotonically increasing and exponentially increasing are presented in Figure A1 and Table A1 (in the online supplementary material, at https://doi.org/10.1080/02508060.2019.1617535) and the general case in Figure 1. The four combinations of the relationship between the benefits function and the transaction cost function shapes are explained in Table 1.

Examples are many. The riparians sharing the multilateral Mekong, Ganges, La Plata, Nile and Jordan Rivers have struggled to reach basin-wide agreements for many years. In the case of the Jordan and Ganges, some of the riparians signed sub-basin accords (in 1994 between the Hashemite Kingdom of Jordan and Israel, and in 1996 between Bangladesh and India) instead of basin-wide agreements. Similarly, upstream China has been hesitant to participate in the basin-wide agreement leading to the 1995

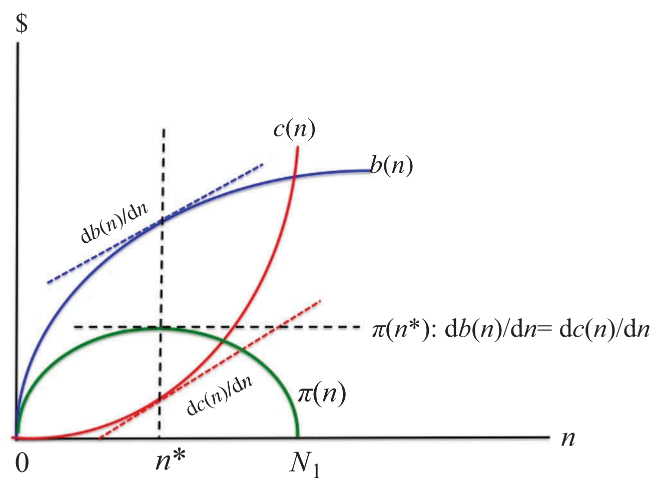

Figure 1. Illustrative example of the derivation of the payoff function and the optimal number of riparian states in the treaty.

Table 1. Meaning of the curvature of the benefits and transaction cost functions.

Benefits function		Transaction cost function	
Strong monotonic increase	Weak monotonic increase	Strong exponential increase	Weak exponential increase
Cooperation is characterized by a substantial incremental gain by any new player that joins the coalition in the basin.	Cooperation is characterized by not so much attractive gains as the number of players increases. It may be attractive up to a given number of players cooperating, but from there on, the additional gains are insignificant.	Transaction costs increase exponentially with the number of players in the coalition. From a given point on the scale of the number of players, any additional player adds very significant transaction costs by joining the coalition.	Transaction costs increase as the number of players in the coalition increases. But this increase is incrementally small.

Mekong River Basin Treaty. In this particular basin, downstream riparians have formed smaller coalitions to cooperate over the basin.[4]

Next we introduce our data and specifications of the empirical models, and discuss some of the other real-life conditions that affect the creation of coalitions and treaties in international river basins.

Empirical specifications and hypotheses

We develop several empirical models that are aimed at showing the role of benefits and transaction costs in the treaty outcomes. The empirical models depart from the results we obtained using the stylized model and several results from previous work we reviewed; we also include several control variables that provide the needed empirical explanation used in the literature.

Our empirical modelling framework consists of several sets of variables. We start with *treaty scale*, which is a measure of economies of scale associated with the number of riparian states in the treaty. We also include a set of variables for *treaty content*, which is a measure of the issue areas addressed by the treaty. We identify them by the number of developmental issues included in the treaty (infrastructure development, hydropower, fishing, groundwater, irrigation, and navigation) – *total treaty issues*, a count of how many of them exist in the treaty. We then focus, in separate models, on the existence (or not) of *environmental* and *water allocation*, measured as a dichotomous variable (yes/no). We also account for the number of institutional features included in the treaty. In designing institutions, states can develop institutional frameworks with the ability to exchange information, monitor the river's development, resolve conflicts, design enforcement procedures, agree on joint management, and establish a river basin organization. We measure the degree of treaty institutional self-regulation by counting the number of institutional features included, which is the level of institutionalization or *total treaty institutions*. We control for the *negotiation context*[5] by borrowing from Zawahri et al. (2014) a set of variables that identify bilateral treaties signed over bilateral basins (*BTBB*); bilateral treaties signed over multilateral basins (*BTMB*), multilateral treaties signed over multilateral basins (*MTMB*) and basin-wide treaties signed over multilateral basins (*BWTMB*). Following Dinar et al. (2015), we introduce two sets of variables that measure the *transaction cost* of negotiating and maintaining the treaty, by using information on newsworthy events between riparian states over their shared basin. These events can involve disputes over the shared basin or cooperation in developing the basin. These news events are classified on a scale from conflict to cooperation between the two members of the basin dyad. A detailed description of the *transaction cost* variables is provided in the next section. The last component in our empirical model includes a vector of *Control* variables (described in the next section) that we borrow from Zawahri et al. (2014).

Our set of empirical models includes the following generic relationships (five models):

[1] *treaty scale* = f_1 (*negotiation context, control*)

[2] *treaty content* (*environment*) = f_2 (*treaty scale, transaction cost, negotiation context, control*)

[3] *treaty content* (*allocation*) = f_3 (*treaty scale, transaction cost, negotiation context, control*)

[4] *treaty content* (*institutionalization*) = f_4 (*treaty scale, transaction cost, negotiation context, control*)

[5] *treaty content* (*total treaty issues*) = f_5 (*treaty scaletransaction cost, negotiation context, control*)

Based on the discussion in the review of previous works, we expect the following relationships between independent variables and the dependent variable:

[6] $\frac{\partial(treaty\ content)}{\partial(treaty\ scale)} \leq 0\{for\ treaties\ with\ environment\ or\ water\ allocation\ issues\}$

[7] $\frac{\partial(treaty\ content)}{\partial(transaction\ cost)} \leq 0\{for\ treaties\ with\ environment\ or\ water\ allocation\ issues\}$

[8] $\frac{\partial(treaty\ content\ (institutionalization))}{\partial(treaty\ scale)} \geq 0$

[9] $\frac{\partial(treaty\ content(institutionalization))}{\partial(transaction\ cost)} \geq 0$

[10] $\frac{\partial(treaty\ content(development\ issues)}{\partial(treaty\ scale)} \geq 0$

[11] $\frac{\partial(treaty\ content(development\ issues)}{\partial(transaction\ cost)} \leq 0$

Data and variables

We merge three data-sets that have been published in the literature. We describe the data-sets as well as how the data was coded and merged.

Treaty data-set

Here we provide general information on the construction of the data-set (Zawahri et al., 2014). The treaty data are from an updated version of the Transboundary Freshwater Dispute Database (TFDD),[6] which includes treaties signed from 1945 to 2007. The data-set is constructed using the dyad-year form because it helps us capture the relationship between the treaty content and the negotiation context (the number of riparian state signatories to an agreement and the number of riparian states in the basin). Each dyad is coded with its signature date, states in the dyad, number of basin riparians and number of treaty signatories. We excluded treaties that were negotiated by colonial powers on behalf of others; we also excluded conventions that do not focus on a specific basin. We retained treaties between states and political entities in transition to a state status (e.g., Palestinian

Authority, Eritrea), because at the time of the negotiation they had autonomous status. The treaty data-set we use consists of 392 treaties and 1,333 dyads. Of the dyads, 149 negotiated *BTBB*; 257 negotiated *BTMB*, 732 negotiated *MTMB*, and 195 negotiated *BWTMB*.

Two water event data-sets

We use a combined measure of cooperation and conflict as a proxy for the transaction costs of treaty negotiation and implementation. The assumption underlying this methodological choice is that the greater the conflict in a basin in the past, the harder it will be to overcome the resistance of the riparians to reach an agreement. This measure will allow us to estimate our proposed models and hypotheses that were introduced earlier. We take advantage of two existing data-sets: the TFDD International Water Events Database (IWED) and the International Rivers Cooperation and Conflict database (IRCC).

The IWED was established under the framework of the TFDD's Basins at Risk project (BAR) at Oregon State University (Yoffe et al., 2003) and was updated in 2008 (De Stefano et al., 2010). The updated version IWED contains 2,586 events of interaction between dyads of riparian countries globally in 1948 to 2008. Each event is coded according to its intensity using the BAR scale, which ranges from −7, the most conflictive level (war), through 0 (neutral events), and up to +7, the most cooperative (voluntary merging of countries).

The IRCC, developed by Kalbhenn and Bernauer (2012), uses an approach similar to that of Yoffe et al. (2003) and De Stefano et al. (2010). However, the IRCC covers events in 1997–2007 and characterizes water-related events between riparian countries on a scale from −6 (most conflictive) to +6 (most cooperative). At present, it includes 4,797 events worldwide. This data-set was used by Beck, Bernauer, Siegfried, and Bohmelt (2014) and by Bernauer and Bohmelt (2014) to predict future conflict and cooperation events.

Since the coding forms of the two data-sets (IWED and IRCC) are not directly comparable, it was not feasible to merge them. After considering different options, e.g., using the Oregon State University data-set for 1948–2006 and the IRCC one for 1997–2007, we applied our modelling approach to each data-set separately, to maximize both data-sets and also to have the opportunity to compare the results from different data-sets to test the robustness of our argument.[7]

Using the three data-sets

As is the practice in analyzing water interactions in international basins (e.g., Brochmann & Hensel, 2011; Zawahri et al., 2014), we use dyadic data-sets that include interactions between any two riparian states in the basin. The reason for using dyadic data is twofold. First, currently all the available data-sets use a dyadic approach, and data availability is a key consideration when designing a methodology. Second, dyadic data directly reflect interactions between pairs of countries but indirectly also provide information about interactions in the whole basin. If a given interaction involves, say, three riparians (countries A, B and C), the data-sets will report it as three events: one for dyad A/B; one for dyad B/C and one for dyad A/C. Thus, the multilateral dimension is indirectly contained in the data-set. We contend that if the basin as a whole has a history of non-cooperation, it will be more difficult to reach multilateral agreements even if tension is concentrated between only two of the riparians. This is because it will be very difficult to have the two conficting two riparians join an agreement, whether bilateral or multilateral. Thus, the BAR and IRCC values are seen as proxies for general animosity in the basin, which is associated with a cost that has to be overcome to sign a multilateral agreement. Our hypothesis is that the greater the general animosity, the higher the transaction costs to achieve cooperation.

We prepared the event data by coding all the events in both data-sets using the same basin_country dyad codes to identify each pair of countries and the shared river (e.g., DANU_DEU_HUN, for Danube_Germany_Hungary). Event intensity (EI) was measured by the variables BAR_value in the IWED data-set and IRCC_value in the IRCC data-set. The IWED and the IRCC data-sets were combined with the treaty data-set into one overall data-set for our analysis. Dyads with no events registered in either of the sub-data-sets were excluded from the analysis.

Variable construction

We developed several measures of *Treaty Scale* to represent the potential or actual number of riparians included in the treaty as a proxy for the economies of scale of the treaty outcome.

N_1= number of riparian states in the basin

N_2= number of riparian states signing the treaty

$$N_3 = \frac{N_2}{N_1}$$

We expect that N_i (i = 1, 2, 3, …) will have a negative effect on inclusion of certain treaty issues (e.g., environment and water allocation), as discussed earlier.

In each of the two event sub-data-sets (IWED/BAR and IRCC) we generated several proxy variables to reflect transaction cost in each dyad: number of positive events (EI > 0); number of negative events (EI < 0); number of events with EI > +1; number of events with EI < −1; average EI of positive and negative events (0 excluded); average EI of all events (0 included); and average of the anti-logged equivalent of EI. The latter approach was used also in previous studies using BAR event data (e.g., Brochmann, 2012; Dinar et al., 2015; Yoffe & Larson, 2001). The specific variables we developed include, for [*i*] = *BAR, IRCC*:

TNE_[*i*] = total number of events reported for the dyad (number of positive events + number of negative events + number of neutral events). This is an integer 0 or greater (0 means no events reported).

AVE_WITHOUT 0_[*i*] = average of the [*i*] values without considering the events with [*i*] = 0.

AVE_WITH 0_[*i*] = average of the [*i*] values considering also the events with [*i*] = 0. (AVE_WITHOUT 0_[*i*] emphasizes the negative and positive interactions, while AVE_WITH 0_[*i*] the sign of interactions (positive or negative) will be somehow diluted by the neutral events.)

AVE_ANTILOG_[*i*] = average of the [*i*] value after expressing the [*i*] values as antilog (expressing the value x of the event as e^x). Using the antilog imposes a difference between large and small [*i*] values. For instance, the difference between the antilog of 2 and the antilog of 1 (4.63) is smaller than the difference between the antilog of 6 and the antilog of 5 (249.9), Thus, more extreme events, which normally are rarer and also of higher concern, are emphasized.

We imported from Zawahri et al. (2014) the treaty/basin dummy treaty context consisting of *BTBB, BTMB, MTMB*, and *BWTMB* variables. *MTMB* is used as the benchmark. We do not have prior expectations of the sign of the coefficient of *BTBB, BTMB, MTMB*, but we expect a negative sign for the *BWTMB* coefficient, which implies a lower intercept compared with the benchmark negotiation context.

We also imported several of the control variables (reported to be significant) from Zawahri et al. (2014). We use the Composite Index of National Capability (CINC)[8] to measure relative state capability, which will enable us to examine the impact of state power. CINC is a statistical measure of state power that uses the average of six different state-to-world ratios (total population; urban population; iron and steel production; primary energy consumption; military expenditure; and military personnel). Since values are measured as ratios for each of the six variables, they are comparable. The state CINC is an aggregated number measured as a percentage; the higher the value, the stronger the state's capabilities. CINC1 and CINC2 represent the state capabilities of the upstream and downstream riparians, respectively. Drawing on the findings of Zawahri and Mitchell (2011) and Crow and Singh (2000), we expect that CINC1 and CINC2 will have a negative impact on the dependent variables of Models 1, 2, 3, 4 and 5 since greater capability will induce a state not to cooperate as the number of negotiating states increases. Powerful states prefer to negotiate bilaterally to secure their interests (Zawahri and Mitchell, 2011). We also measured the state 'welfare power' for the upstream and downstream states – *upstreampower* and *downstreampower*, respectively. We use GDP per capita. Higher GDP per capita indicates a higher efficiency of the economic system of a state, and thus greater welfare power of that state. As suggested by Zawahri et al. (2014), we expect that these two variables will each have a positive impact on the dependent variable of Model 1 and a negative impact on the dependent variable of Models 2, 3, 4, and 5. We also examine the impact of regime type. Drawing on democratic peace theory, Zawahri and Mitchell (2011) argue that greater democracy across the dyad state reduces the transaction costs of negotiating and maintaining a treaty. We use the variable *lowpolity* from Zawahri et al. (2014), which captures the difference between the lowest democracy minus autocracy in the dyad. Data are from the Polity IV database.[9] Using weakest-link logic in calculating each dyad score, the lowest value for each state in the dyad is used. We expect that *lowpolity* will have a negative effect on the dependent variable in Model 1 and a positive impact on the dependent variable in Models 2, 3, 4 and 5.

As is expected in the literature (Mitchell & Powell, 2009), states with homogeneous legal systems and traditions will have lower transaction costs in their negotiation process. To consider the impact of a state's legal structure, we use a measure, *samelegal*, drawn from the Mitchell and Powell (2009) database, of the type of legal tradition found in individual states. *samelegal* is 1 if the two states have similar legal systems, and 0 otherwise.

The last control variable we imported measures the involvement of international environmental non-governmental organizations (IENGOs) in the basin, which are expected to lower the transaction cost of treaty formation. This comes from data compiled by David John Frank, which consists of a random sample of 24 environmental IENGOs drawn from the Union of International Association Yearbook for 1987–88 and 2007–08. Constructing membership data at the state level, the database includes every fifth IENGO.[10]

Using weakest-link logic in calculating each dyad score, we use the smallest number of such organizations for both states in the dyad. The variable *IENGO* is expected to positively affect the dependent variables in Models 1, 2, 3, 4 and 5.

The variable *environmental regulation* is 0 if it is not mentionedin a treaty and 1 if it is. The variable *water allocation* is 0 if allocating the basin's waters is not mentioned and 1 if it is. Logit estimation is used in models where these are dependent variables. The variables *total treaty institutions* and *total treaty issues* count the number of institutional features and issues, respectively, included in the treaty. General linear model (GLM) estimation is used. We use ordinary least squares (OLS) estimation for continuous dependent variables such as N_3.

Results

The summary statistics of the variables included in our analyses are presented in Table A2 (in the online supplementary material). While the number of dyad-treaty observations in our data-set is 1,333, only 843 observations have IRCC values, and only 573 have BAR values. Table A2 presents the descriptive statistics of these subsets.

We start with predictions of the number of treaty signatories (N_2) and the ratio of signatories to basin riparians (N_3) in the signed treaties (Model 1, Table 2). Regression

Table 2. Prediction of number of treaty signatories and ratio of treaty signatories to riparians in the basin.

Model	1	1
Regression	2.1	2.2
Estimation procedure	GLM	OLS
Dependent Variable	N_2	N_3
BTBB	−3.630***	0.299***
	(−18.11)	(18.20)
BTMB	−4.286***	−0.273***
	(−31.95)	(−13.31)
BWTMB	−0.866**	−0.259***
	(−3.03)	(−23.23)
CINC1	−32.291**	−2.036**
	(−2.45)	(−2.50)
CINC2	−34.446**	−3.918***
	(−2.54)	(−3.90)
upstreampower	24.911+	1.999**
	(1.87)	(2.36)
downstreampower	31.163*	2.585***
	(2.36)	(3.25)
lowpolity	−0.089***	−0.006***
	(−8.63)	(−6.56)
samelegal	0.012	−0.041***
	(0.07)	(−3.03)
IENGO	0.006	0.001
	(0.28)	(0.70)
Constant	6.414***	0.724***
	(41.12)	(55.23)
Observations	725	725
Log (pseudo) likelihood	−1488.21	
F-test		273.19***
R^2		0.646
$R(\rho)^2$	0.577	

Significance levels: *** = 0.1%; ** = 1%; * = 5%; + = 10%.

2.1 estimates the relationship for N_2 using a GLM procedure (due to the count nature of N_2), and regression 2.2 uses an OLS procedure because N_3 includes real numbers. The two models have the expected results in terms of the signs of the independent variables, and significant coefficients except for the variable *IENGO*. Remembering that *MTMB* is used as a benchmark treaty context, all treaty context variables (*BTBB, MTMB, BWTMB*) in the two models are significant. Regressions 2.1 and 2.2 yield similar results in terms of explanatory power, significance and signs (of most variables). However, regression 2.2 provides more significant results, and thus we focus on that regression in reporting the results. *BTBB* and *BWTMB* are obviously the contexts that would suggest the potential for the highest ratio of signatories to basin riaparians. Therefore, the coefficients of these variables are positive, while the coefficient of *BTMB* is negative. The CINC1 and CINC2 variables are negative, suggesting, as expected, that higher capabilities of the riparian state will lead to a lower likelihood of participation in the basin-wide treaty. This is consistent with the findings in the literature that in multilateral basins powerful riparians prefer to negotiate sub-basin accords as opposed to multilateral or basin-wide accords (Crow & Singh, 2000; Hensel, Mitchell, Sowers, & Thyne, 2008; Lautze & Giordano, 2005; Zawahri & Mitchell, 2011). Through sub-basin accords, powerful states can secure their own interests and prevent the formation of coalitions that may upset their success. The *upstreampower* and *downstreampower* variables also behave as expected, with significant and positive coefficients, suggesting that welfare power has a positive impact on the ratio of signatories to basin riparians. This finding suggests that more welfare power in the basin increases the likelihood of reaching a treaty (Dinar et al., 2015). We also find that *lowpolity* has a negative and significant coefficient, suggesting that the more authoritarian one of the states in the dyad is, the less likely it is that the riparians will sign a treaty. Alternatively, the more democratic the dyad is, the more likely it is to sign a basin-wide treaty. This finding is consistent with democratic peace theory and other research on the relationship between regime type and treaty formation (Zawahri & Mitchell, 2011). We obtained an unexpected result regarding the coefficient of *samelegal*, which is significant but negative, suggesting that basins that include riparian states with similar legal systems are less likely to see a larger share of the riparian states signed to the treaty. This result contradicts the finding in the literature of lower costs of negotiating and reaching an agreement given a shared legal tradition. Finally, *IENGO* was not significant, suggesting that the presence of such NGOs in a basin does not aid treaty formation. This also contradicts the existing literature.

We further present the relationships that explain the inclusion of basin issues in the treaty – Models 2 and 3 in Table 3; Models 4 and 5 in Table 4. Because of space limitations, we include only representative results.[11]

All models in Tables 3 and 4 produce the expected results. While the proxy variables for economies of scale (N_1 and N_2) and the measures of transaction costs (*average_antilog_BAR; average_antilog_BAR_squared, average_antilog_IRCC, average_without 0_BAR*) are significant in all models, several control variables were not significant in all models. We will focus our discussion on the transaction cost variables and on variables N_1 and N_2.

For Models 2 (Regression 3.1) and 3 (Regressions 3.2–3.4), the linear term of the transaction cost variable is positive, and the quadratic term is negative. We expected the transaction

Table 3. Inclusion of basin issues in the signed treaty.

Model	2	3	3	3
Regression	3.1	3.2	3.3	3.4
Estimation procedure	Logit	Logit	Logit	Logit
Dependent Variable	environment	allocation	allocation	allocation
average_antilog_BAR			0.012+	0.016*
			(1.89)	(2.19)
average_antilog_BAR_squared			−4.580e-5+	−6.10e-5*
			(−1.77)	(−1.95)
average_antilog_IRCC	0.012+	0.016*		
	(1.76)	(2.21)		
N_1		−0.191***		−0.104*
		(−3.71)		(−1.99)
N_2	−0.571***		−0.645***	
	(−7.05)		(−5.21)	
BTBB	−1.779***	−1.165*	−0.908	0.426
	(−3.65)	(−2.00)	(−1.51)	(0.62)
BTMB	−1.042**	0.322	−0.807*	1.045**
	(−3.03)	(0.88)	(−1.93)	(2.54)
BWTMB	−0.837**	−0.927*	−0.739+	−0.662
	(−2.44)	(−2.40)	(−1.64)	(−1.37)
CINC1	16.038	23.694+	26.850*	34.443*
	(1.02)	(1.79)	(1.98)	(2.30)
CINC2	7.603	21.787	22.364	33.340+
	(0.42)	(1.35)	(1.38)	(1.84)
upstreampower	−12.756	−19.835	−26.973+	−33.668*
	(−0.79)	(−1.44)	(−1.91)	(−2.16)
downstreampower	−11.716	−20.910	−24.947+	−33.236*
	(−0.73)	(−1.53)	(−1.75)	(−2.12)
lowpolity	2.36e-3	0.023	−8.48e-3	0.04
	(0.12)	(1.16)	(0.35)	(0.17)
samelegal	0.175	0.303	0.183	0.362
	(0.67)	(1.23)	(0.58)	(1.18)
IENGO	−0.056	−0.081+	−0.177*	−0.170*
	(−1.20)	(−1.69)	(−2.31)	(−2.23)
Constant	1.018**	−0.531	1.241*	−1.394*
	(2.41)	(−0.96)	(2.16)	(−2.24)
Observations	725	725	490	490
Log-likelihood	l−278.91	−297.39	−184.05	−204.57
LR χ^2	84.41***	83.39***	54.95***	64.75***
Pseudo-R^2	0.155	0.099	0.196	0.107

Significance levels: *** = 0.1%; ** = 1%; * = 5%; + = 10%

cost function to be exponentially increasing, but our estimates suggest that the linear term is positive (instead of negative). Our interpretation is that the transaction cost function increases with a decreasing marginal rate up to a point, but after a peak, it falls. This is not exactly the shape of the transaction cost function we referred to in the theoretical model, but still, the increasing part of the transaction cost function is significantly large, and the negative quadratic part is minute. Therefore, we can accept this functional form for our empirical analysis. This suggests that, as the transaction cost of reaching and maintaining a treaty increases, the likelihood of having environmental regulation and water allocation included in a treaty declines. The sign of the economies of scale variables (N_1 and N_2) in Regressions 3.1–3.4 is negative and significant, as expected. This suggests that as the number of riparians in the basin (N_1) or the number of signatories (N_2) increases, the likelihood of having environmental or water allocation in the treaty falls. Addressing environmental problems and allocating the basin's water involves enforcement problems (due to the ease of cheating), which become more difficult as the number of riparian states increases, and it increases the

Table 4. Total treaty institutions and issues.

Model	4	5	5
Regression	4.1	4.2	4.3
Estimation procedure	GLM	GLM	GLM
Dependent Variable	total treaty issues	total treaty institutions	total treaty institutions
average_antilog_BAR	−8.683e-4+		2.87e-4+
	(−1.78)		(1.72)
average_without 0_BAR		0.027***	
		(1.78)	
N_1	0.046*		
	(2.10)		
N_2		0.082*	0.082**
		(2.43)	(2.40)
BTBB	−0.220	−0.723*	−0.719*
	(−0.84)	(−2.15)	(−2.13)
BTMB	−0.367*	−0.543*	−0.548*
	(−2.15)	(−2.21)	(2.23)
BWTMB	−0.545***	−1.357***	−1.359***
	(−3.35)	(−6.80)	(−6.81)
CINC1	1.078	10.346	10.177
	(0.22)	(1.31)	(1.30)
CINC2	0.732	12.938	12.707
	(0.09)	(1.28)	(1.27)
upstreampower	−1.264	−13.652*	−13.592+
	(−0.24)	(−1.66)	(−1.66)
downstreampower	−0.524	−14.609*	−14.559+
	(−0.11)	(−1.84)	(−1.84)
lowpolity	0.021*	0.051***	0.051***
	(1.95)	(4.64)	(4.63)
samelegal	−0.071	−0.253+	−0.251+
	(−0.55)	(−1.70)	(−1.64)
IENGO	−0.055*	0.012	0.012
	(−2.15)	(0.40)	(0.41)
Constant	1.021***	2.423***	2.742***
	(3.97)	(8.08)	(8.75)
Observations	490	490	490
Log (pseudo) likelihood	−794.27	−872.29	−872.43
$R(\rho)^2$	0.068	0.208	0.207

Significance levels: *** = 0.1%; ** = 1%; * = 5%; + = 10%.

transaction cost of negotiating and maintaining treaty commitments (Tir & Stinnett, 2012; Zawahri et al., 2014).

The marginal analysis (Figure 2) indicates the extent of the change in the likelihood of including either environmental regulation or water allocation in the negotiation processes, based on Regressions 3.1 and 3.3, respectively. As more states join the treaty (as N_2 grows from 2 to 10 states in our analysis), the likelihood of having either environmental regulation and water allocation ultimately increases, though its coefficient stays negative. More specifically, the likelihood of having water allocation in a treaty rises more rapidly as more states join the treaty than environment regulation, consistent with the existing river management practices, where water allocation attracts more nations coming on board to negotiate over a common resource than to deal with environment regulations. Quentin, Chu, Stewardson, & Kompas (2011) reported evidence of poor ecological conditions in river management as a result of water allocation for irrigated agriculture.

For Models 4 and 5, the coefficients of the economies of scale variables (N_1 and N_2) are positive and significant, as expected, suggesting that the larger the number of

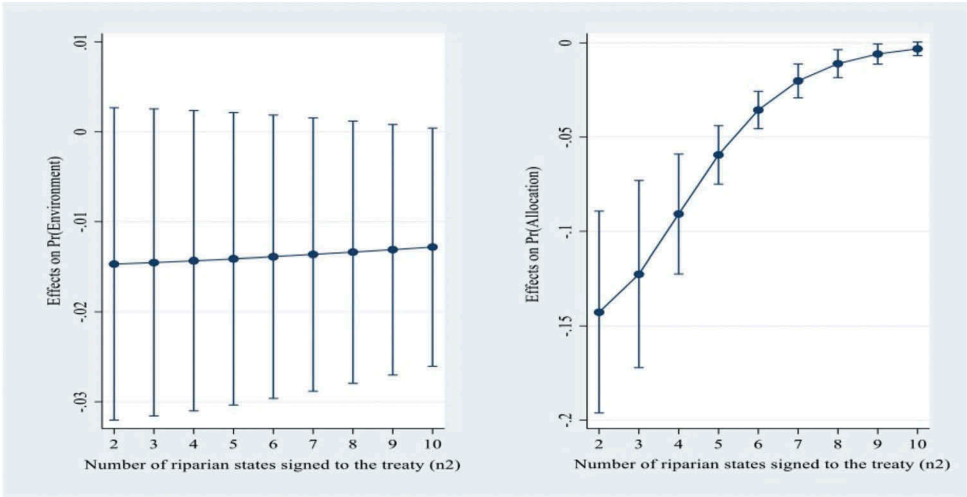

Figure 2. Average marginal effect of number of treaty-signing states on likelihood of inclusion of environment and allocation issues.

riparians (N_1) or the larger the number of signatories (N_2), the more likely that treaties will include development issues, because the economies of scale of the development projects are more attractive. Another factor pushing up the probability that riparian states will agree on economic development issues is that it allows states to distribute gains from cooperation (Zartman, 1994). Such treaties will also include more institutional design features, but for a different reason: to introduce more sustainability to a treaty that is signed between a large number of signatories and to manage the difficulties of maintaining future cooperation, consistent with theories of international relations (Drezner, 2000; Verdier, 2008). As expected, in Model 4 (Regression 4.1) the coefficient of the transaction cost variable is negative, suggesting that higher transaction costs make it less attractive for the signatory states to address the various development issues in the treaty. In Model 5 (Regressions 4.2 and 4.3), the coefficient of the transaction cost variable is positive and significant, as expected, suggesting that as the transaction cost increases, more institutional features are introduced to sustain the agreement, consistent with arguments by Drezner (2000).

We turn now to discuss the results for the control variables in all estimated regressions. The results (using a logit estimating procedure) in Table 3 are for Regressions 3.1–3.4, which estimate the likelihood of including environmental regulation (Model 2) and water allocation (Model 3) in the treaty. Several control variables in these models, such as *lowpolity* and *samelegal*, are not significant in any regression. Other control variables have the expected signs and are significant in one to three of the regressions. Similar results were found by Zawahri et al. (2014). The coefficient of *lowpolity* in Regression 3.1 is positive, as expected, but not significant in Regressions 3.2 and 3.3.

The results in Table 4 are for Model 4 (Regression 4.1) and Model 5 (Regressions 4.2 and 4.3), using a GLM procedure. In Regression 4.1 the transaction cost variable has a negative and significant coefficient, suggesting, as expected, that as transaction cost increases the treaty will include fewer issues. This could be due to the high cost of negotiating over complex issues and sustaining cooperation with treaty commitments when more than two states are involved. The extreme case is where the treaty is very vague (like the La Plata 1966 treaty), making only a general statement. In Regressions 4.2 and 4.3, the transaction cost variable has a positive coefficient, suggesting that higher transaction costs increase the number of institutional features in the treaty, consistent with our theory that the higher the cost of negotiating and sustaining the treaty, the more institutions are needed. The coefficients of the economies of scale variables N_1 and N_2 are positive and significant, as expected. The coefficients of CINC1 and CINC2 are not significant in any of the regressions in Table 4. The remaining control variables have the expected sign and are significant in one to three of the regressions. The coefficient of *lowpolity* is positive, as expected, suggesting that weaker democracy in the basin will result in more institutional mechanisms built into the treaty. The variable *samelegal* has a negative coefficient (Regressions 4.1 and 4.2), suggesting that states with similar legal traditions are less likely to invest in institutional design to sustain cooperation with treaty commitments.[12]

For a robustness check, we introduce instrumental variables (IV) for some of the explanatory variables that most likely have endogenous effects without directly affecting the dependent variable of interest. For instance, we expect that the number of treaty signatories, used as and economies of scale variable, will depend on the size of the basin (*basinsize*) without affecting environmental regulation or water allocation. Also, the transaction cost variables are expected to be affected by the number of treaty issues under consideration. Our methodology uses two-stage estimation: first generating fitted variables after netting out the IVs' effect, and then running a second regression with the fitted and exogenous variables on the dependent variables (Baum, 2006).[13]

We identified several variables in the models in Tables 3 and 4 that had to undergo the IV procedure. The independent variable N_2, representing scale in Regressions 3.1, 3.3, 4.1 and 4.2, could be, possibly, endogenously determined. The same concern could be raised regarding the variables that represent transaction costs, *average_antilog_BAR, average_antilog_BAR_Squared*, *average_antilog_IRCC*, and *ave_without 0_BAR*, in Regressions 3.1–3.4 and 4.1–4.3. We use ln(*basinsize*) as the instrument for *N2*, and the number of issues mentioned in the treaty, *total treaty issues*, as the instrument for variables with BAR and IRCC values. These estimates are then inserted into the equations in Regressions 3.1–3.4 and 4.1–4.3 to produce the unbiased model estimates and are reported in Tables A3-IV and A4-IV (in the online supplementary material) for those IVs used.

The IV analyses indicate that the transaction cost variables become more significant and positively affect individual treaty issues (environmental regulation or water allocation, as shown in Table A3-IV). After introducing IV, transaction costs variables now strongly affect the total treaty issues, but the number of signatories is now a less important factor in treaty issues (Table A4-IV). As for the remaining independent variables, except the two variables in Table A3-IV, all kept their sign, but several variables are associated now with a lower level of significance, as indicated in note 12. Also, almost all regressions with IV have better fit according to all criteria. Hence, introducing IV improved the performance of our models.

Discussion, conclusion and policy implications

The nature of managing global public goods (or bads) such as climate change and global CO_2 pollution, and that of common pool resources, such as international rivers and transboundary aquifers, suggests that there are situations under which the cost of cooperative management of the goods/bads/resources (what we defined as transaction costs) exceeds the cooperation benefits (defined as economies of scale). The present analysis attempts to understand the determinants of reaching or not being able to reach a basin-wide agreement over shared water. As noted earlier, despite the importance of basin-wide accords, it appears that states tend to prefer fragmented governance of multilateral basins. Moreover, we lack knowledge about the factors influencing the formation of basin-wide accords and the content of these contracts. The lack of this information prevents us from helping states develop the basin in an economically efficient manner and internalize externalities.

We developed a theoretical framework to address that question and applied it with empirical extensions to data on existing treaties among riparian states sharing international river basins. We hypothesized that, depending on the nature of the treaty, one can expect different incentives to join the agreement.

We found that the number or share of riparian state signatories to the agreement is significantly affected by the control variables we used, except *samelegal* and *IENGO*. The effects were also in the direction we expected: greater state capabilities (CINC1 and CINC2) lead to fewer signatories; greater state welfare power (*upstreampower* and *downstreampower*) lead to more signatories; and *lowpolity*, a measure of the difference in governance/democracy, suggests that the less democratic the dyad within the basin, the less likely it is that they will reach a basin-wide treaty. These findings are consistent with arguments in the literature, mainly that powerful states prefer fragmented governance, while democratic dyads increase the probability of multilateral negotiation (Crow & Singh, 2000; Zawahri & Mitchell, 2011).

In the following, we discuss the results that address our main hypotheses (Table 5): the effects of transaction costs and economies of scale on the structure of the treaty. We found that transaction costs increase the likelihood of treaties with environmental regulation, and greater economies of scale lead to fewer treaties that include environmental regulation. Transaction costs raise the likelihood of treaties with water allocation, but economies of scale have the opposite effect. Transaction costs tend to reduce the number of issues included in the treaty, while economies of scale tend to increase it. Higher transaction costs tend to increase the number of institutional mechanisms incorporated in a treaty, and greater economies of scale increase the number of treaty institutions for managing the expanded cake. We do not discuss here the findings on the control variables, since we

Table 5. Summary of qualitative effects of transaction costs and economies of scale on the signed treaty structure.

Treaty issue(s)	Transaction cost coefficients	Economies of scale coefficients
Environment	+	–
Allocation	+	–
Total issues	–	+
Total institutions	+	+

wanted to focus on transaction costs and economies of scale. As indicated in the Results section, the control variables mostly behaved as expected.

What can we conclude and recommend as a result of this analysis? Our findings reconfirm the findings of Zawahri et al. (2014), who focused on the impact of the negotiation context on the treaty content. Indeed, we see that multilateral negotiation contexts are different from bilateral contexts in that the multilateral treaty focuses on less transaction-cost-related issues, contains fewer issues under the same treaty, and builds support systems in the form of institutions to help maintain future cooperation. These findings confirm previous work on the importance of the transaction costs of negotiating and sustaining treaties, along with the need to invest in institutional design to address transaction costs (Drezner 2000; Keohane, 1986; Verdier, 2008).

By adding the economies of scale and the transaction cost variables to our estimated models we were able to move the discussion from the charcteristices of the involved states to the nature of the interaction among the states. Our findings are very similar to those of the studies on international environmental agreements that focus on CO_2 pollution in the context of climate change. The overall conclusion in that the net payoff from cooperation (benefits affected by economies of scale minus transaction costs) can diminish as the number of basin states increases, which would explain the smaller number of basin-wide agreements as the number of riparians in the basin increases. Increasing the benefits becomes more difficult, given the engineering and landscape constraints and the landscape of possible intervention sites in the basin. This is an important finding, given the absolute lack of empirical knowledge about the formation of basin-wide accords. This finding generates policy advice to provide more room and opportunities to address transaction costs, and thus increase the net payoff. Transaction costs may be reduced through the mediation of third parties, improved inter-state relations and interactions, issue linkages that foster trust between riparian states, and expanding the negotiation space (scope).

Adding options to reduce transaction costs will be the focus of a simulation-based paper we plan for future research. We also plan several improvements to the model by considering additional specifications of the transaction cost variable and combining the observations in the two data-sets (BAR and IRCC) so that we have transaction cost variables that span a longer period, rather than only the periods covered by each of the transaction cost variables in this article. The overall findings of this article demonstrate the useful interaction between economics and international relations considerations, supporting the theories in each of these disciplines.

Notes

1. Negotiations in the La Plata covered hydropower, navigation, flood control and water supply; negotiations in the Mekong included hydropower, irrigation, navigation and environmental pollution; negotiations in the Nile and Aral Sea addressed hydropower, irrigation and environmental pollution.
2. Stronger (weaker) monotonically increasing means that the benefit function increases faster (slower) as an additional riparian joins the agreement; stronger (weaker) exponentially increasing means that the transaction cost function increases faster (slower) as an additional riparian joins the agreement.

3. The support for the shape of the benefit function and the transaction cost function, leading to this result is found in the literature we cited and discussed in section 1.
4. Recently the Mekong Basin states engaged in consultation and agreements to move towards a basin-wide management model. While this process is still in its infancy, it is a major step forward (Biba, 2018).
5. Underlined variables mark a vector.
6. http://www.transboundarywaters.orst.edu.
7. It is important to keep in mind the difference in time periods between the two data-sets. The IRCC data are for 1997–2007, while BAR data covers 1948–2008. This suggests that the BAR data are more representative of the relations that existed when many of the treaties were signed.
8. http://correlatesofwar.org/.
9. http://www.systemicpeace.org/polity/polity4.htm.
10. Readers interested in more information on the data used for the variable IENGO are referred to Zawahri and Mitchell (2011) and to Zawahri et al. (2014). The IENGO data can be provided upon request from the corresponding author of this paper.
11. All regression results for various specifications and for the IRCC-transaction and BAR-transaction cost variables are available from the corresponding author on request.
12. We minimized the elaboration on the results of the control variables beyond what was written above, for two reasons. First, the results (sign and significance level) are very similar to those in Zawahri et al. (2014), so the reader is referred to that work. Second, due to space limitations and the focus of this article on transaction costs and economies of scale, we wanted to provide more discussion on these latter variables.
13. One of the drawbacks of this methodology is that it may produce higher standard errors and lead to an outcome where some variables are less significant or insignificant.

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