LINKING THE UNLINKED: TRANSBOUNDARY WATER-SHARING UNDER WATER-FOR-LEVERAGE NEGOTIATIONS

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We develop a game-theoretic framework of negotiation over sharing of trans-boundary resources between neighboring countries. The downstream country offers a non-water "leverage" good in exchange for water access and makes a take-it-or-leave-it offer to the upstream country. The downstream country can further invest in water provision before the negotiations. We compare three types of outcomes: the first-best outcomes where an "ex-ante social planner" choses both the water investment and the water and leverage goods exchanged in the negotiations; the outcome when an "ex-post social planner" only enters at the negotiation stage; and the outcome of bilateral negotiations. We argue that all three cases can be empirically realistic; show that the outcome with the ex-post social planner can distort the downstream country's investment incentive; and that the bilateral negotiation outcome can lead to water investment either below or above the efficient/ex-ante planner's preferred choice. (JEL: F53, F51, Q25, R41)

Key words: Trans-boundary water sharing, issue-linkage, negotiation.

INTRODUCTION

Increasing fresh water scarcity may lead to increasing conflict over controlling its common sources, such as Trans-boundary Rivers in agricultural economies. While upstream countries may release water for altruistic, geopolitical or other strategic reasons, the lack of formal agreements leave downstream countries exposed to changing situational factors that they cannot control. This can make their water access unpredictable (Giordano and Wolf 2003; Bhaduri and Barbier 2008a,b). Under specific circumstances, however, countries can negotiate water access for either access to other water sources or non-water goods and services. We develop a framework to study negotiation through linking unlinked issues. In particular, we contribute in this line of literature by introducing pre-negotiation investment in water resource management when assuming that water-conflicting countries negotiate over water and leverage goods. We then link our theoretical results with several ongoing water negotiations in South and Central Asian regions.

There are 261 international rivers causing political tensions among the neighboring countries across the globe, between, for example, Arabs and Israelis, Indians and Bangladeshis, Americans and Mexicans, and all ten riparian states of the Nile River (Wolf 1998). However, rather than leading to wars, most of these water conflicts are resolved through negotiations.[1] In practice, the tendencies of countries to cooperate on water-sharing often seem to reflect negotiations over interconnected issues rather than the desire of upstream countries to surrender their water voluntarily. For example, Mexico agreed to share the Rio Grande if the US shared the Colorado River under the US-Mexico International Boundary Water Treaty of 1944 (Ragland 1995). India and Pakistan engaged in water-for-water sharing under the 1960 Indus River Treaty (Alam 1998). Moreover, countries may be able to trade water for non-water goods and services (Barrett 1994; Kroll, Mason, and Shogren 1998). For example, Bennett, Ragland, and Yolles (1998) suggests that the five Central Asian Republics can potentially reach agreements to share the water in the Aral Sea basin and its tributaries via multi-issue negotiations, that is, by linking the water issue with negotiations over important non-water issues, such as air pollution, international trade, and civil conflict spillovers. In this paper, we will refer to non-water goods and services which are used to bargain for water as *leverage goods*.

The existing literature on multi-issue negotiations models water-for-water or water-for-leverage agreements in an infinitely repeated game with a discrete strategy space and a prisoners' dilemma structure (Barrett 1994; Bennett, Ragland, and Yolles 1998; Kroll, Mason, and Shogren 1998). If any country fails to deliver in its promised issue dimension in the current period, no country will deliver in the other dimensions in the future. In this paper, we simplify the analysis by abstracting from the contract enforcement issue, but we extend the literature by using a continuous strategy space. Instead of asking whether or not the countries will honor a particular agreement, therefore, we study the determinants of the agreement, that is, the determinants of the volumes of water and leverage goods countries will trade.[2] Since we are able to predict how

[1] However, the only clear instance of an outright war was 4500 years ago between two Mesopotamian city-states, while countries signed more than 3600 water treaties during 805-1984 (Wolf, Yoffe, and Giordano 2003).

[2] e.g., the countries may be able to write a binding contract or have high enough discount factors to enforce it in a repeated game.

changes in the economic and ecological environment will affect the equilibrium trade volumes, we can predict how empirical water agreements are likely to respond to economic and environmental shocks. We also extend the analysis to a two-stage game where the downstream country can invest in domestic water provision prior to negotiating international water sharing with the upstream country. We can therefore ask how the water investment affects the negotiations and vice versa.

The outline of the reminder of the paper is as follows. Section I develops the theoretical model. Section II presents the theoretical results. Section III provides empirical evidence in support of our theoretical results. Finally, Section IV draws on policy implications and concludes.

I. A MODEL OF LINKED ISSUE NEGATIONS[3]

We study two neighboring countries that negotiate over two commodities of common interest, water and the leverage good. The water-rich upstream country controls the source of a water-flow such as an international river. It negotiates over the sharing of water with the water-scarce downstream country that owns a leverage good. In order to make the analysis concrete, we focus on the case of negotiations over water from the Teesta River between India and Bangladesh. We assume that, if India is willing to increase Bangladesh's access to water from the Teesta River, Bangladesh can compensate India with transit services. The transit services will make it easier for India to transport goods to its politically troubled Northeastern states by shipping the goods through Bangladesh.

Due to the lack of substitutes and the cultural and political significance of water, we assume that the marginal utility from water increases as water becomes scarce, so there is diminishing marginal utility from water in the downstream country. In order to simplify the analysis, but without losing generality, we further assume that the upstream country has constant marginal utility and the downstream country has an increasing marginal cost of providing the transit service. Since the only way to get a corner solution in the model is if the upstream country is unwilling to trade water and we wish to focus on situations with gains from trade, we prefer to focus on the set of interior rather than corner solutions.

[3] Our model also applies to countries trading on any set of natural resources while having imperfect (in quantity, and maybe in quality, too) domestic substitutes. We credit Sam Fankhauser for pointing at this aspect of our work.

The downstream country has two sources of water, including international river water from the upstream country (w) and a composite alternative source (ω), which might include rainfall, groundwater and domestic surface water. Before the water-for-transit negotiations, the downstream country can invest in domestic water provision, i.e., it can increase ω. For example, it may be able to invest in reforestation, restoration and better management of flows in existing water bodies. The investment cost is $\psi(\omega), \psi' > 0, \psi'' > 0$. The downstream country's benefit from water is $(w + \omega), b' > 0, b'' < 0$, and its cost of providing transit volume t to the upstream country is $\varphi(t), \varphi(0) = 0, \varphi' > 0, \varphi'' > 0$. Thus, the net benefit of the downstream country is

$$(1) \qquad \mathrm{U(w,t) = \ b(w + \omega) - \varphi(t) - \psi(\omega).}$$

Without an agreement, $w = t = 0$ and the downstream country gets $b(\omega) - \psi(\omega)$.

The upstream country's benefit is linear in the transit services it receives t. Its cost of giving up water is $\phi(w), \phi(0) = 0, \phi' > 0, \phi'' > 0$. Thus, the net benefit of the upstream country is

$$(2) \qquad V(w, t) = t - \phi(w).$$

We assume that the downstream country makes a take-it-or-leave-it offer of water for transit services.

II. SOLUTION

We consider two types of solutions in this section: the efficient outcome implemented by a benevolent social planner and the private negotiation equilibrium. When we study the social planner's solution, we consider the case where the social planner optimizes the downstream country's ex-ante water investment as well the case where the social planner takes the ex-ante investment as a given. The solution for the ex-ante social planner determines the theoretically optimal solution for water investment, water and transit trade. The solution for the ex-post social planner may be more realistic when a third party, such as the World Bank or an outside country, seeks to mediate the water dispute. In that case, the mediation effort may only begin after the downstream country has already invested in water provision and the mediator will then be tempted to impose the ex-post efficient outcome. We show that imposing the ex-post efficient outcome can distort the ex-ante incentive for investing in water provision. Given this, a private negotiation situation where the downstream country has substantial bargaining power can improve its water investment incentive compared to the ex-post efficient outcome. To demonstrate this point, we focus on the extreme case where the downstream country can make a take-it-or-leave-it offer, which implies that it has all the bargaining power.

A. The Social Planner's Solution

The social planner maximizes social welfare (defined as the unweighted sum of the two countries' benefits). However, we consider both the case where the social planner takes the water investment as a given – acting as an "ex-post" social planner – and the case where the social planner also optimizes with respect to the water investment. We believe that both cases may be realistic. In particular, third party mediators in water conflicts may only attempt to mediate the dispute once it arises rather than engage before the conflict becomes visible, which is when the downstream country makes its water investment in the model.

The ex-post social planner solves

$$\max_{w,t} B = b(w+\omega) - \varphi(t) + t - \phi(w),$$

which yields the first-order conditions:

$$(3) \qquad b'(w+\omega) - \phi'(w) = 0 \qquad \text{and} \qquad 1 - \varphi'(t) = 0,$$

which determine the socially optimal values w^s and t^s. The optimal water exchange is determined by equating the marginal benefit of water of the downstream country and the marginal cost of water to the upstream country, $b' = \phi'$. The optimal transit exchange equates the marginal benefit of the upstream country to the marginal cost of the downstream country, $1 = \varphi'$. These results lead to Propositions 1 and 2.

Proposition 1. *An increase the domestic water supply (i) does not affect the optimal transit trade; (ii) decreases the optimal water trade. That is,* $\frac{dt^s}{d\omega} = 0$ *and* $\frac{dw^s}{d\omega} < 0$.

Proof.

(i) From (3), $\varphi'(t) = 1$ determines optimal transit independently of the domestic water supply ω. Thus, $\frac{dt}{d\omega} = 0$.

(ii) From (3), $(b'' - \phi'')dw = -b''d\omega \Leftrightarrow \frac{dw}{d\omega} = \frac{-b''}{(b''-\phi'')} \in (-1,0)$.

Proposition 2. *The social planner only partly rewards the downstream country for its domestic water supply. That is,* $\frac{dU}{d\omega} < b'(w^s + t^s)$.

Proof. We have $\frac{dU(w(\omega),t(\omega),\omega)}{d\omega} = \frac{dU}{dw}\frac{dw}{d\omega} + \frac{dU}{dt}\frac{dt}{d\omega} + \frac{dU}{d\omega}$. Now, from (3) and the proof of proposition 1, $\frac{dU}{dw} = b'$, $\frac{dw}{d\omega} = \frac{-b''}{(b''-\phi'')}$, $\frac{dU}{dt} = -\varphi'$, $\frac{dt}{d\omega} = 0$, $\frac{dU}{d\omega} = b'$. Substituting these into the previous equality shows that $\frac{dU}{d\omega} = b'\left(1 - \frac{b''}{b''-\phi''}\right) = \frac{-\phi''b'}{b''-\phi''} < b'$.

Proposition 1 and Corollary 1 show that the ex-post social planner chooses the water sharing arrangement independently from the transit exchange. Moreover, if the downstream country invested in water provision, the ex-post planner would allocate a part of the investment benefit to the upstream country to equate the marginal water utilities across the countries. If the downstream country anticipates that the ex-post social planner will allocate the water, it has an inefficiently weak incentive to invest in water provision. It only invests until $\frac{\mathrm{dU}}{\mathrm{d\omega}} = \frac{-\phi''b'}{b''-\phi''} < \mathrm{b}'$.

The solution to the ex-ante social planner’s problem is

$$\max_{w,t,m} B = b(w+\omega) - \varphi(t) + t - \phi(w) - \psi(\omega).$$

The first-order conditions are (3) and an optimality condition for investment,

(4) $$b'(w+\omega) - \psi'(\omega) = 0.$$

(3) and (4) jointly imply that the ex-ante planner would like to increase the domestic water investment until the marginal social benefit of water equals the marginal social cost of water provision, $b'(w+\omega) = \phi'(w) = \psi'(m)$. As we explained above, however, Corollary 1 shows that, once the investment cost has been paid, the ex-post social planner has an incentive to share the marginal investment payoff between the two countries. If the ex-post social planner determines the water-for-transit allocation, therefore, the downstream country has a weak incentive to invest in water provision: it will only invest until the marginal cost equals the marginal private return, rather than the marginal social return, i.e., until $\psi'(\omega) = \left(\frac{-\phi''(w)}{b''(w+\omega)-\phi''(w)}\right) b' < b'(w+\omega)$.

B. Private negotiation equilibrium

While Proposition 1 shows that the efficient water and transit allocations are separable, it contrasts with the outcome when the downstream country makes a take-it-or-leave-it offer, which we now study. In this case, despite the separable utility functions, any change in the water allocation is always accompanied by a changing leverage volume, i.e., the water and transit supplies co-vary.

Since the downstream country makes a take-it-or-leave-it offer, it maximizes its benefit (1) subject to the upstream country's participation constraint, which states that the upstream country's payoff (2) must be non-negative, $t \geq \phi(w)$. It is optimal to satisfy this condition with equality, so $t = \phi(w) \Rightarrow w = w(t), w' > 0, w'' < 0$. The downstream country maximizes (1) subject to $t = \phi(w)$,

$$\max_t U = b(w(t) + \omega) - \varphi(t) - \psi(\omega).$$

The first-order condition is

$$(5) \qquad b'(w(t) + \omega)w'(t) - \varphi'(t) = 0,$$

which determines the optimal transit t^*. The downstream country equates its marginal benefit from receiving water with the marginal cost of providing transit i.e., $b_1' w' = \varphi'$.

Proposition 3. *The water and transit supplies co-vary as the economic environment changes. Particularly, as the water investment ω increases, smaller amounts of water and transit services will be traded.*

Proof. The participation constraint binds, $t = \phi(w) \Longrightarrow dt = \phi' dw \Longrightarrow dw = (1/\varphi')dt$, where $(1/\varphi') > 0$. Thus, w and t co-vary. Next, to show the effects of an increase in the water investment, we write (5) as $H\big(\omega, t(\omega)\big) = b'(w(t) + \omega)w'(t) - \varphi'(t) = 0$. Now, by the implicit function theorem

$$\frac{dH}{d\omega} + \frac{dH}{dt}\frac{dt}{d\omega} = 0 \Rightarrow \frac{dt}{d\omega} = \frac{-dH/d\omega}{dH/dt} = \frac{-b''w'}{b''(w')^2 + b'w'' - \varphi''} < 0,$$

where $b''(w')^2 + b'w'' - \varphi'' < 0$ is the second-order condition for t. Now, since $\frac{dt}{d\omega} < 0 \Longrightarrow \frac{dw}{d\omega} = (1/\varphi')\frac{dt}{d\omega} < 0$, an increase in the water investment decreases w, therefore, smaller amounts of water and transit services will be traded.

Going backward, we can solve for the optimal pre-negotiation investment by the downstream country. Once the downstream country chooses the optimal transit volume t^* in the negotiation state, its maximized payoff is

(6) $$U = b(w(t^*) + \omega) - \varphi(t^*) - \psi(\omega).$$

By the envelope theorem, the marginal utility gain from of an increase in ω is $b'(w(t^*) + \omega) - \psi'(\omega)$, where the envelope theorem implies we can ignore the effect on t^*. In the investment stage the downstream country increases ω until the marginal payoff gain just stated is zero, so it solves

(7) $$b'(w(t^*) + \omega) - \psi'(\omega) = 0.$$

Proposition 4. *Consider the values of w and ω solving (5), (7) and $t = \phi(w)$. If $\phi'(w) > \varphi'\big(\phi(w)\big)$, then the ex-ante social planner chooses smaller values of water exchange and water provision w and ω than the downstream county chooses in the bilateral negotiations. Otherwise the planner chooses more water exchange and transit.*

Proof. Combing (5), (7) and the participation constraint $t = \phi(w)$, the downstream country solves

(8) $$b'(w + \omega) = \psi'(\omega) = \varphi'(\phi(w)),$$

for w and ω. On the other hand, the ex-ante social planner solves (3) and (4)

(9) $$b'(w + \omega) = \psi'(\omega) = \phi'(w),$$

for w and ω. Consider now the values of w and ω solving (7). If $\phi'(w) > \varphi'\big(\phi(w)\big)$ – meaning the marginal loss for the upstream country (which the ex-ante/efficient social planner cares about) exceeds the marginal transit cost (which the downstream country cares about) - the social planner chooses smaller values of water exchange and water provision w and ω than the downstream county chooses in the bilateral negotiations. Otherwise the planner chooses more water exchange and transit.

III. DISCUSSION, EXAMPLES AND A CASE STUDY

Although the ex-ante social planners' solution is by definition efficient, as we noted in Proposition 2, the downstream country may have a weak investment incentive if the negotiation is determined by the ex-post social planner. Interestingly, the bilateral negotiations can lead the downstream country to invest either more or less than the efficient amount in water before the negotiations. The reason is that the water investment can strengthen its bargaining position and this effect may be strong enough to generate overinvestment. However, it may also be weak enough to cause underinvestment compared to the efficient level.

In practice, sometimes modeling water negotiations using the ex-post or even the ex-ante social planner assumption may be realistic. These scenarios may be most likely when there is a third party mediator. On the other hand, it can be difficult to find a mediator and each country (including especially the country with the strongest bargaining power without the mediator) may veto the mediator. After all, international organizations such as the World Bank and United Nations do not have control over decisions made by individual countries. In this case, countries may negotiate themselves to resolve conflicts, and then form a platform to oversee the enforcement and execution of the agreement. Examples include the 1960 Indus Water Treaty, 1996 India-Bangladesh Ganges River Treaty and US-Mexico 1944 Water Treaty.

An example of international water-sharing executed by a "social planner' is the World Bank-mediated 1960 Indus Water Treaty between India and Pakistan. After the partition of India in 1947, the two countries engaged in disputes over the sharing of the Indus Valley Rivers, all of which are sourced in India. Amid Pakistani fear of getting deprived of water-rights, the World Bank mediated the Indus Water Treaty, allocating both India and Pakistan water-rights over three rivers each: Ravi, Satluj and Beyas to India and Sindh, Jehlam and Chenab to Pakistan (World Bank 1960). However, Pakistan received 80 percent of the Indus River water (Alam 1998). Albeit having few wars since 1960, these two hostile neighbors remain complicit to the agreement ever since.

India and Bangladesh signed the Ganges Treaty in 1996 to resolve issues of sharing the water of the Ganges River. The treaty allocates water with considerations for both the seasonal and between years variations in water flows on Ganges at Farakka, and, thereby, ensured India to release water downstream to Bangladesh from Farakka to meet the downstream water flow obligations. The joint river commission, formed in 1973, manages all the water-related treaties between India and Bangladesh.

On the other hand, United States of America and Mexico signed a water-for-water agreement under the 1944 US-Mexico Water Treaty to share and manage the waters of the Colorado and Tijuana Rivers, and of the Rio Grande (Rio Bravo) from Fort Quitman, Texas, to the Gulf of Mexico. International Boundary and Water Commission (IBWC) was given full responsibility for carrying out the treaty and ensuring both sides met obligations and maintained rights delineated within the treaty. The commission was explicitly assigned to conduct studies on the capacity for flood control and hydroelectric power generation in the region of the Rio Grande (Rio Bravo) and Colorado rivers, and to make recommendations with regards to the joint management of Tijuana River.

The CIS-7 countries (Armenia, Azerbaijan, Georgia, the Kyrgyz Republic, Moldova, Tajikistan and Uzbekistan) from Central Asia are unequally endowed with natural resources, which has been linked to recurrent conflict between them since their separation from the USSR in 1991. However, the unequal resource distribution of resources can potentially give rise to mutually beneficial trades (Bennett, Ragland, and Yolles 1998). For example, Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan enjoy rich energy reserves, while Armenia, Georgia, the Kyrgyz Republic and Tajikistan have substantial water resources. Our modeling framework suggests that these countries can adopt mutually beneficial water-for-energy and energy-for-water transactions, which may mitigate their scarcity problems.

A CASE STUDY OF THE TEESTA RIVER BASIN

Although India and Bangladesh share water from 54 international rivers, 53 of which flow from India to Bangladesh (Dutta 2010), the only formal agreement is the Ganges River Treaty of 1996. Such overwhelming majority of rivers flowing from India to Bangladesh makes it impossible for these two countries to negotiate water-for-water; and, therefore, makes our framework of water-for-leverage a practical suggestion. Recently, these two countries are negotiating over, among other issues of common interest, the sharing of Teesta River water and transit through Bangladesh to economically connect the Northeastern Indian States with the Mainland India.

Teesta River is a critical component in the relationship between these two South Asian neighboring countries (Ahmed 2012), both of whom are predominantly dependent on agriculture. In 2014, agriculture accounts for 16.1 percent and 17.8 percent of GDP in Bangladesh and India (World Bank 2015). The Teesta basin contained 14 percent of Bangladesh's total cropped area in 2001 and 63 percent of these lands depended on irrigation from river water. The construction of the upstream Teesta barrage in Gajoldoba in 1979 led India to withdraw more water, leaving less for the downstream Teesta barrage in Dalia in Bangladesh. Since 21 of the 29 million people who live in the basin are Bangladeshi (Islam and Higano 2001) and India already irrigates all its 527,000 ha lands with irrigation potential, while Bangladesh only irrigates about 20-perecent of its 540,000 ha lands with potential, Bangladesh has demanded a greater water share.[4] Recent rainfall declines have also increased river reliance in both countries (IPCC 1997; Wahid et al. 2007).

On the other hand, if India becomes able to ship goods via Bangladesh, the mainland will become better connected to the Northeastern states. The ground transit has been closed since the 1965 India-Pakistan war, which has forced India to rely on expensive air and sea transit as well as much longer land routes (Dutta 2010).[5]

Bangladesh and India are yet to reach an agreement over Teesta River water sharing, historically; and, in 2011 Bangladesh has denied transit to India in response. Against this backdrop, we propose that these countries can potentially use water-for-transit and transit-for-water transactions within our modeling framework to resolve the long-standing dispute over the sharing of Teesta River water.

IV. CONCLUSIONS

We design a game where neighboring countries can link seemingly unlinked issues to resolve existing and potential conflicts on natural resources of common interest such as water, pollution,

[4] Historically India's share of the Teesta River water has been roughly 75 percent, but Bangladesh has demanded its 25 percent share increase to 48 percent. The fresh water supply in the Teesta Basin depends on the river water, groundwater and monsoon rain.

[5] Prior to the agreement proposed in 2011, the Indian states of West Bengal, Assam, Mizoram, Meghalaya and Tripura identified 13 road routes through Bangladesh for the transportation of cargo, passengers and personal vehicles registered in India.

trade and transit. Within our modeling framework, the downstream country offers a non-water "leverage" good in exchange for water access and makes a take-it-or-leave-it offer to the upstream country. The downstream country may invest in water provision before the negotiation. We show that pre-negotiation investment can affect the outcomes of the water-for-leverage negotiation through increasing the negotiation power of the water-scarce country, and, therefore, providing strategic benefits.

In the first-best solution when an "ex-ante social planner" choses both the water investment and the water and leverage goods exchanged in the negotiations, we find that the efficient water and leverage allocations are separable since the social planner treats the conflicting countries as a single unit when maximizing social welfare. In this case, pre-negotiation investment does not affect the optimal leverage allocation (Proposition 1), which is true as well for the solution by an "ex-post social planner". Although the water-scarce country does not gain any strategic benefit since the social planner only partly compensates the downstream country for its domestic water supply (Proposition 2), it is always optimal to invest in pre-negotiation management of alternative water source since it affects the efficient water allocations. However, the downstream country has a weak incentive to invest in water provision under "ex-post social planner": it will only invest until the marginal cost equals the marginal private return, rather than the marginal social return. That is, the outcome with the "ex-post social planner", who only enters at the negotiation stage after the pre-negotiation investment decisions are made, can distort the downstream country's investment incentive.

On the other hand, water and leverage allocations co-vary under bilateral negotiation, resulting in strategic benefits from pre-negotiation investment for the water-scarce country (Proposition 3). Interestingly, the bilateral negotiations can lead the downstream country to invest either more or less than the efficient amount in water before the negotiations. The reason is that the water investment can strengthen its bargaining position and this effect may be strong enough to generate overinvestment. However, it may also be weak enough to cause underinvestment compared to the efficient level. Therefore, bilateral negotiation outcome can lead to water investment either below or above the efficient/ex-ante planner's preferred choice.

The analysis of our results has important implications for agricultural and environmental decision-making of a downstream country dependent on its upstream neighbor. The costly management of alternative water sources may trigger environmental degradation since a major component of these sources is groundwater. In particular, in some cases, over-extraction of groundwater may even increase the arsenic contamination. Therefore, while pre-negotiation investments are important because of the presence of strategic benefits, it is also important to adopt environment-friendly modes of investment.

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