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POLICY RESEARCH WORKING PAPER 1303

# Conflict and Cooperation in Managing International Water Resources

Can negotiated treaties ensure that nations which share bodies of water share gains from cooperation? Often, but not always — and sometimes only partly.

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## Summary findings

Water is often not confined within territorial boundaries so conflicts may arise about shared water resources. When such boundaries lie within a federal state, conflicts may be peacefully and efficiently resolved under law, and if the states fail to reach an agreement, the federal government may impose one.

Similar international conflicts are more difficult to resolve because no third party has the authority to enforce an agreement among national states, let alone impose one.

Such international agreements must be self-enforcing. Efficient outcomes may emerge, but are not guaranteed.

International law may emphasize the doctrine of "equitable utilization" of water resources, but there is no clear definition of what this implies.

In the Colorado River case, the polluter (the United States) agreed to pay for all the costs of providing the downstream neighbor (Mexico) with clean water.

In the Rhine River case, the downstream country (the Netherlands) agreed to pay part — but not all — of the costs of cleanup.

In the Colombia River Treaty case, both parties agreed to incur construction costs on their side of the border and share evenly the gross (not the net) benefits. This division may well have yielded a smaller net benefit to the United States than unilateral development would have, but the United States ratified the treaty.

Negotiated outcomes need not maximize net benefits for all countries. To some extent, inefficiencies can be traced to the desire to nationalize resources rather than to gain from cooperative development. The Indus Waters Treaty, for example, divided the Indus and its tributaries between India and Pakistan, rather than exploit joint use and development of the basin.

Both efficiency and equity should be considered in agreements for managing international water resources. The 1959 Nile Waters Agreement between Egypt and Sudan did not reserve water for upstream riparians — notably, Ethiopia. A basinwide approach could make use of Nile waters more efficient and benefit all three riparians: Egypt, Ethiopia, and Sudan. Construction of dams in Ethiopia would give that country irrigation, would eliminate the annual Nile flood, and would increase the total water available to Ethiopia and Sudan. In negotiations over use of the Nile, the net benefits of basinwide management, and the ways these three riparians could share equitably in gains, should be demonstrated.

In the 1980s, Egypt did not run short of water because Sudan did not take its full allocation and because Ethiopia did not withdraw any water from the basin. Increased water demand will inevitably create tension between these states.

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# CONFLICT AND COOPERATION

# IN MANAGING

# INTERNATIONAL WATER RESOURCES

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# CONFLICT AND COOPERATION IN MANAGING INTERNATIONAL WATER RESOURCES

by Scott Barrett

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## 1. Introduction

Water resources are "international" if they are "common to several States" (Caponera, 1980). Examples include rivers and lakes which border two or more countries, rivers which flow from one country into another, and shared ground water resources.[1] In all such cases, use by one country of the shared water resource affects the quantity or quality available to another country.

This interdependence is both great in extent and pervasive. As Table 1 shows, there are about 200 shared river basins, distributed more or less evenly across the African, American, Asian, and European continents.[2] While most of these are shared by only two countries, 13 are shared by 5 or more countries, and 4--the Congo, Danube, Nile and Niger basins--are shared by 9 or more countries.[3] According to United Nations (1978), international river and lake basins make up about 47 percent of the world's continental land area. On the continents of Africa, Asia, and South America, shared river and lake basins make up at least 60 percent of the total land area. Shared groundwater resources are also common, and many acquifers underly several countries.[4]

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[1]The United Nations (1975) includes "atmospheric water" and "frozen water resources" as further examples.

[2]United Nations (1978) lists 214 internationally shared river basins. The discrepancy between the two estimates could be due to differences in definition. United Nations (1978, p.2) notes that "Discrepancies between basin areas given in this report and those from other sources can be attributed to different interpretations of the location of the watershed." Whatever the reasons for the discrepancy, since the number of countries and their borders has changed since these two inventories were taken, these aggregate figures should not be taken to be accurate but indicative of the actual number. However, it should be noted that both sets of figures are controversial. Biswas (1993, p. 171) argues that the number of international river basins is significantly higher than 214:

> "A good example of this serious undercounting could be indicated by the number of international rivers between India and Bangladesh. The UN study identified only one mega-basin, the Ganges-Brahmaputra, which is shared not only by India and Bangladesh but also by China, Nepal and Bhutan. It should be noted that during one of the past meetings of the India-Bangladesh Joint Rivers Commission, Bangladesh identified more than 140 water systems that are common to both countries."

[3]According to United Nations (1978), the Danube is shared by 12 countries, including three which have since been reconfigured: the USSR, Yugoslavia, and Czeckoslovakia.

[4]The Northeastern African aquifer underlies Libya, Egypt, Chad, and Sudan. The Northern Sahara Basin is shared by Algeria, Tunisia, and Libya. The Chad aquifers are shared by Chad, Niger, Sudan, Nigeria, and Cameroon. Another aquifer lies beneath Saudi Arabia, Bahrain, Qatar and the United Arab Emirates. Groundwater resources are also shared by countries in Europe, Southeast Asia, the Indian Subcontinent, and Latin America. See Vlachos (1990).

**TABLE 1**

**Number of Shared River Basins by Region**

| | | Number of Countries Sharing the Basin | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Area[1]** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **Total** |
| Africa | A | 3 | 2 | 6 | - | 2 | 1 | - | 3 | - | 17 |
| | B | 30 | 8 | - | - | - | - | - | - | - | 38 |
| Americas | A | 10 | 2 | - | 1 | - | 1 | - | - | - | 14 |
| | B | 43 | 3 | - | - | - | - | - | - | - | 46 |
| Asia | A | 7 | 5 | 2 | - | 2 | - | - | - | - | 16 |
| | B | 20 | 3 | 1 | - | - | - | - | - | - | 24 |
| Europe | A | - | 2 | - | 1 | - | 1 | - | - | 1 | 5 |
| | B | 35 | 5 | - | - | - | - | - | - | - | 40 |
| Total | A | 20 | 11 | 8 | 2[2] | 4[3] | 3[4] | - | 3[5] | 1[6] | 52 |
| | B | 128 | 19 | 1 | - | - | - | - | - | - | 148 |
| | | 148 | 30 | 9 | 2 | 4 | 3 | - | 3 | 1 | 200 |

Notes: [1] Area A (B) comprises more (less) than 100,000 square kilometers
[2] La Plata, Elbe
[3] Chad, Volta, Ganges-Brahmaputra, Mekong
[4] Zambezi, Amazon, Rhine
[5] Niger, Nile, Congo
[6] Danube

Source: Panel of Experts on the Legal and Institutional Aspects of International Water Resources Development (1975), Annex VII.

Interdependence is particularly acute for some countries. Table 2 lists the countries which rely most on waters originating in other countries. Egypt obtains all its water from the Nile, 97 percent of which originates in other countries. The vast majority of the countries listed in the table are low- or middle-income economies; only 6 of the 31 countries listed in Table 2 are high-income economies.[5]

When there is international interdependence, there is no guarantee that the allocation of water resources will be efficient. To take a famous example, consider the "prisoners' dilemma" game, shown in Figure 1a. There are two countries, A and B. Both share a common aquifer, and both face a binary choice: to extract the water at a High or Low rate. Within each cell, the number on the left is A's payoff and the number on the right is B's. Each country prefers a higher payoff to a lower payoff, but does not care one way or the other what payoff the other country receives. Despite this assumption of self-interest, the two countries are interdependent insofar as each country's realized payoff depends not only on its own choice for a rate of extraction but also on the choice made by the other country.

**FIGURE 1**
**(a) Prisoners' Dilemma Game**

| | | B: Low | B: High |
|---|---|---|---|
| A | Low | 5,5 | 2,6 |
| A | High | 6,2 | 3,3 |

What strategy should the players pursue? Consider first player A. Because of the interdependence that exists, player A, in deciding whether to choose High or Low, will wish to consider how the payoffs it receives depends on player B's strategy. Suppose B chooses Low. Then A receives a payoff of 5 if it chooses Low and a payoff of 6 if it chooses High. The latter payoff is greater, and so given that B chooses Low, A's best response is to choose High. Suppose now that B chooses High. Then A receives 2 if it chooses Low and 3 if it chooses High. Again, the latter payoff is greater, and so given that B chooses High, A's best response is to choose High. But this means that A should choose High *whatever B chooses*. Choosing

[5] Income classifications are taken from World Bank (1992).

**TABLE 2**

**Dependence on Imported Surface Water**

| Country | Percent of Total Flow Originating Outside of Border | Country | Percent of Total Flow Originating Outside of Border |
|---|---|---|---|
| Egypt | 97 | Iraq | 66 |
| Hungary | 95 | Albania | 53 |
| Mauritania | 95 | Uruguay | 52 |
| Botswana | 94 | Germany | 51 |
| Bulgaria | 91 | Portugal | 48 |
| Netherlands | 89 | Yugoslavia | 43 |
| Gambia | 86 | Bangladesh | 42 |
| Cambodia | 82 | Thailand | 39 |
| Romania | 82 | Austria | 38 |
| Luxembourg | 80 | Pakistan | 36 |
| Syria | 79 | Jordan | 36 |
| Congo | 77 | Venezuela | 35 |
| Sudan | 77 | Senegal | 34 |
| Paraguay | 70 | Belgium | 33 |
| Czechoslovakia | 69 | Israel[1] | 21 |
| Niger | 68 | | |

Notes: [1] Although only 21 percent of Israel's water comes from outside current borders, a significant fraction of Israel's fresh water supply comes from disputed lands, complicating the calculation of the origin of surface water supplies. This percentage would be affected by a political settlement of the Middle East conflict.

Source: Gleick (1992), Table IV, p. 18.Table 1

High is therefore a *dominant* strategy. Since the game is symmetric, choose High is also a dominant strategy for B. The (Nash) equilibrium to this game is thus for both players to choose High and to receive a payoff of 3 each. Notice, however, that both parties would receive higher payoffs if they both chose Low. The equilibrium to the game is inefficient.

Of course, this much is well known. But what is novel about such situations in international relations? After all, aquifers are also shared by local communities and states. To see the novelty, consider the following solution to the dilemma. Suppose that both parties negotiate an agreement which specifies that if either party chooses High, it would have to pay a fine to the other party equal to 2. Then the game appears as in Figure 1b. If B chooses Low and A doesn't, A receives apayoff of 6, as in the original game, but must now pay a fine of 2: hence, A's payoff becomes 4. B receives a payoff of 2 plus the fine for a total payoff of 4. The payoffs are the same if A chooses Low and B chooses High. It can now be seen that the best strategy for each player is to choose Low, whatever the other player chooses. The agreement thus makes choosing Low a dominant strategy. The equilibrium to the altered game is thus efficient.

**Figure 1**

**(b) Prisoners' Dilemma Game with Penalties for "Cheating"**

| | | B: Low | B: High |
|---|---|---|---|
| A | Low | 5,5 | 4,4 |
| A | High | 4,4 | 3,3 |

However, to effect such an outcome requires much more than the mere existence of such an agreement. What is required is that the agreement be *binding* on both parties. In an intranational dispute, parties which freely commit to an agreement can be made to comply with the terms of the agreement by the courts. And of course the enforcement of contracts is one of the principal functions of judicial systems. In an international dispute, however, agreements between countries cannot be enforced by a third party. International agreements must be self-enforcing. Self-enforcement is a severe constraint, and may mean that international water resources potentially cannot be managed as efficiently as intranational resources.

The nature of the interdependence that exists among countries can be complex, and often bares little resemblence to the prisoners' dilemma game. Many shared water problems are unidirectional, as in the case of upstream countries causing harm downstream. For example, soil erosion in an upstream country may damage dams and port installations downstream. Similarly, use of water upstream for irrigation or as a receptor for pollution reduces the quantity or quality available to downstream countries. However, the externality does not always work in this direction. The construction of dams for irrigation, hydroelectricity production or flood control in a downstream country may cause flooding upstream. Furthermore, international externalities related to water use are not always negative. For example, development of port facilities downstream may benefit upstream countries. Finally, even where externalities are reciprocal, as in the prisoners' dilemma, the nature of the game may well differ: joint development of irrigation, hydroelectric, water transportation or flood control projects can yield all parties greater net benefits than purely nationalistic development, as in the prisoners' dilemma, but economies of scale in the construction of such projects may mean that an inefficient outcome can easily be avoided. While this paper is hardly exhaustive in its coverage, it does consider a number of different forms of interdependence.

The fact that countries are interdependent means that they can potentially be made better off if they can cooperate in managing international water resources, and in practice such cooperation is typically codified in international agreemements. There is, in fact, an astonishing number and variety of such agreements. Two surveys compiled by the Food and Agriculture Organization of the United Nations (1978, 1984) list 3,707 agreements, most of which are bilateral. The first such agreement, a unilateral declaration by Emperor Charlemagne granting freedom of navigation to a monestary, dates back to the year 805. Table 3 lists a number of international water agreements, some of which will be discussed later in the paper.[6]

Of course, the fact that international agreements exist does not mean that they achieve the full cooperative outcome--the outcome where the actions (water extraction rates, pollution emission levels, etc) of parties are chosen to maximize the net benefits of all affected countries taken together (Low, Low in the prisoners' dilemma game). One obvious indicator of the success of an international water agreements is the number of affected countries which are also parties to the agreement. Many agreements are "incomplete" in the sense that the number of parties is less than the number of countries affected. As examples, the Nile is shared by 9 countries, and yet the 1959 Nile Waters Agreement was negotiated by just two, Egypt and Sudan. A 1951 agreement on the Mekong River excluded Burma and China, which share the river's upper reaches, partly because the upper basin was seen to be less attractive for agricultural development and partly because relations between these countries and those in the lower basin (Cambodia, Laos, Thailand and Vietnam) were bad at that time. Paraguay and Brazil cooperated

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[6]There also exist a number of European Community directives relating to water which are not counted in the figures mentioned above or included in Table 3. These directives may also be viewed as international agreements, but they are negotiated within a common institutional environment.

**Table 3: International Water Agreements**

| Agreement | Date of Adoption | Parties | Objective |
|---|---|---|---|
| Revised Convention on the Navigation of the Rhine | 1868 | France, Grand Duchey of Badin, Bavaria, Grand Duchey of Hessin, Holland, and Prussia | To establish a Central Commission for the collective regulation of navigation on the Rhine. |
| Mexico-United States Boundary Waters Convention | 1889 | Mexico, U.S. | To establish an International Boundary and Water Commission, which has the authority to resolve problems relating to the Rio Grande (Rio Bravo) and Colorado Rivers. The 1889 agreement was strengthened in 1944, and the Commission now also prepares plans for flood control and hydroelectric facilities, and regulates the storage of Rio Grande Water. |
| United States-Canada Boundary Waters Treaty | 1909 | Canada, U.S. | To set up the International Joint Commission, which has the authority to rule on applications for particular diversions, obstructions, and other works which affect the boundary waters. |
| Convention to Regulate the Hydro-Electric Development of the International Section of the River Douvo | 1927 | Spain, Portugal | To establish a Commission which would expropriate property to be used for hydroelectric development, and supervise construction and operation of such facilities. |
| Convention Regarding the Regime of Navigation on the Danube | 1948 | Bulgaria, Czeckoslovakia, Hungaria, Romania, the Ukraine,USSR and Yugoslavia | To create three institutions which can manage collective navigation of the Danube. |
| Agreement Between Austria and Bavaria Concerning Austrian-Bavarian Hydroelectric Company | 1950 | Austria, Bavaria | To establish a company, half owned by each of the parties to the Agreement, which is authorized to construct and operate hydroelectric facilities along the frontier, and to produce, sell and distribute the power. |
| Helmand River Delta Agreement | 1950 | Afghanistan, Iran | To create a Commission which would collect and review data on the river, and recommend methods by which Iran's agreed share of the water is to be allocated to Iran. |
| Statute of the Committee for Coordination of Investigations of the Lower Mekong Basin | 1951 | Cambodia, Laos, Thailand, Vietnam | To establish a Committee to facilitate water resources development in the Lower Mekong Basin. |
| Agreement Concerning the Utilization of the Yarmuk Waters | 1953 | Syria, Jordan | To create a Joint Commission which would manage utilization of the Yarmuk Basin, particularly in respect to irrigation and hydroelectricity generation. |
| Agreement on the Kosi Project | 1954 | India, Nepal | To create a Committee which would consider issues relating to the construction by India of hydroelectric, irrigation, flood control and soil erosion preventive facilities on the Kosi River. |
| Agreement on Joint Research Operations on the Amur River Basin and the Argun River | 1956 | USSR, China | To carry out joint research operations to determine the natural resources and the prospects for developing the productive potential of these waters. |
| Agreement Between Yugoslavia and Greece Concerning Hydro-Economic Questions | 1959 | Greece, Yugoslavia | To establish a joint Commission which would study the potential for, and the supervision and inspection of, hydro-economic projects. |
| Agreement for the Complete Utilization of the Nile Waters | 1959 | Egypt, Sudan | To supervise joint research and the construction and operation of approved projects; to draw up working arrangements for works in Sudan and for responding to water shortages; to make arrangements with other countries on the control of the agreed amounts of Nile water consumption; and to negotiate with other riparian countries on matters concerning the Nile. |
| The Indus Waters Treaty | 1960 | India, Pakistan | To establish an Indus Commission to promote cooperation in the development of the shared waters. |
| Act Regarding Navigation and Economic Cooperation Between the States of the Niger Basin | 1963 | Cameroon, Ivory Coast, Republic of Dahomey, Guinea, Upper Volta, Mali, Niger, Nigeria, Chad | To create a Commission to coordinate and promote studies and programmes relating to the utilization and development of the resources of the Niger basin. |
| Convention on the Senegal Basin | 1963 | Mauritania, Guinea, Senegal, Mali | To establish a Committee to regulate navigation, and to coordinate study and work programmes for the development of the Senegal River. Riparian states undertake to notify the Committee of projects which might modify the quantity or quality of the shared waters. |
| Treaty for the Plata Basin | 1969 | Argentina, Bolivia, Brazil, Paraguay, Uruguay | To establish an Intergovernmental Coordinating Committee which would carry out research on the basin, coordinate the exchange of information, and execute decisions taken by the Foreign Ministers. |

in the construction of the Itaipu Dam on the Parana River, but Argentina was not a party to that agreement, even though the dam holds enough water to flood all of north-east Argentina. Finally, an agreement signed by India and Nepal in December 1991 to construct jointly a number of water projects excludes Bangladesh, which is certain to be affected by resulting changes in the flow of the Ganges (Gleick, 1992).

Effective regimes for cooperation in the management of international water resources are important because water is often scarce, and its efficient provision and use is essential to the development of poor countries. Precisely because of this, shared water resources are also a source of international conflict; examples include disputes between India and Pakistan over the Beas-Sutlej and Ravi rivers, between India and Bangladesh over the Ganges waters, between Chile and Bolivia over the Lauca River, between Mexico and the United States over the Colorado, and of course between Israel and its Arab neighbors over the waters of the Jordan.

The purpose of this paper is to develop, and apply, an analytical framework for evaluating the problem of international cooperation in the management of international water resources. Section 2 presents a number of case studies. Section 3 develops a theory of international cooperation applied to water. Section 4 concludes with some final remarks.

## 2. Case Studies

To motivate the paper it will prove useful to begin with some real examples of how international water resources have in fact been managed. The three case studies that follow do not cover all issues that are of interest, and we shall consider further examples later in the paper. What these case studies do provide is a perspective on the political economy of international water resource management.

### 2.1 The Columbia River Treaty

The 1909 Canada-United States Boundary Waters Treaty created the International Joint Commission (IJC), which was empowered to review projects that would affect the flow of boundary waters and to recommend solutions to water resource and other boundary problems. In 1944, after both Canada and the United States had come to understand their mutual interest in developing hydro-power and flood control facilities on the Columbia River, the IJC was instructed to investigate "where in its judgement further development of the water resources of the river would be practicable and in the public interest from the points of fiew of the two governments" (LeMarquand, 1977, p. 6). The IJC made its recommendations in 1959. These included three different proposals for developing the river, and recommended principles for apportioning the net benefits of the development between the two countries. The IJC reports formed the basis for formal negotiations between the two governments, and the Columbia River Treaty was signed in 1961. The treaty was ratified by the United States in this same year, but negotiations between the province of British Columbia and the federal government of Canada delayed ratification by Canada until 1964.

The Treaty has been called a "signal achievement" (Krutilla, 1966, p. 69). Nevertheless, it is remarkable that after 20 years of planning and negotiation between just two countries, a treaty should include projects that are "...uneconomic and unnecessary...." and represent "...a net loss to both countries" (LeMarquand, 1977, p. 53). The reason is primarily due to changes which occurred between the time the treaty was first signed in 1961 and the time it was ratified by Canada three years later. These changes arose from negotiations between the province of British Columbia and Canada.

The Columbia River posed two problems to the United States. One was flood damage (a flood in 1948 killed 50 people and caused more than $100 million in damage). The other was a potential for increased hydro-electricity production. The hydroelectric facilities already on the river were run-of-the-river. By not regulating the flow of water, water passed over the spillways during periods of peak flow. Storage would not only control flooding, but allow water flows to be evened out and hence to increase the total value of electricity production at existing sites. The best sites for water storage were upstream in Canada, and development of these would have the further benefit of substantial hydro-electric power production in Canada.

One reason why the treaty took so long to be accepted was conflict between Canada and its own province of British Columbia. As an example of the game being played out between Canada and British Columbia, the province was in favour of a proposal made by the Kaiser Corporation to build a storage facility in British Columbia and return to the province 20% of the increased power production generated in the United States as a result of the project (Kaiser itself was to receive 50% of this power). The proposal was attractive to the British Columbia government because it would return benefits to the province quickly. However, Canada opposed the scheme because it would reduce the total net benefits of basin-wide development compared with alternative proposals. To block British Columbia's acceptance of the project, Canada passed the International Rivers Improvement Act, which required federal approval for works on rivers which flowed into the United States.

The case illustrates the incentive to make threats, and the problem of making credible threats. The United States believed that the existing *status quo* did not represent the true bargaining position for Canada. While the Canadian side of the basin was largely undeveloped, the United States believed that Canada would have to develop its side of the Columbia to meet its own increasing need for power. Development of hydro power upstream by Canada would effectively regulate the flow of water downstream to the benefit of the United States. Of course it was unlikely that the flow that was most attractive to Canada would also be most attractive to the United States. However, the United States would receive a significant portion of the benefit of coordinated development at no cost.

Partly because of this, Canada considered an alternative development proposal in order to strengthen its bargaining position. This alternative was to divert the Columbia into the Fraser basin. If Canada were to carry out such a diversion, the United States would receive no benefit and would lose the advantages of integrated development of the Columbia basin. However, "...the Fraser diversion was considered too expensive" (LeMarquand, 1977, p. 60). The "...scheme was generally considered impracticable on both sides of the border. Thus its value as a bargaining position was lessened" (LeMarquand, 1977, p. 61). In other words, the threat to divert the Columbai was not *credible*.

Where this threat failed, another succeeded. In the late-1950s, a proposal to develop the Peace River in northern British Columbia was shown to produce the same amount of power as development of the Columbia. The Peace River power would be more costly to deliver to the major consuming areas in the southwest, but would meet the provincial government's objective of developing the north. According to LeMarquand (1977, p. 62):

> "The province made it known that it would postpone development of the Columbia until it received terms that were favourable to the province. This threat was taken seriously by the United States and no doubt helped pave the way to signing of the 1961 treaty."

The province did not drop the proposal to develop the Peace River after the treaty had been signed, because ratification by Canada would require acceptance by British Columbia, and the province used its threat to develop the Peace River to extract better terms from the federal government. The agreement reached between the provincial and federal governments allowed British Columbia to pay for construction of the Columbia River projects by selling its share of the benefits of the agreement to the United States.

Two proposals for dividing the gains to cooperation were considered. The first would subtract the *net* benefits of unilateral action from those of joint action, and share the difference. The second, proposed by the IJC itself, would require that each country "...assume responsibility for providing that part of the facilities needed for the cooperative development that is located within its own territory"; that "Cooperative development of the water resources of the Columbia River basin should result in advantages in power supply, flood control, or other benefits, or savings in cost to each country as compared with alternatives available to that country"; and that "where such sharing would not result in an advantage to each country..., there should be negotiated and agreed upon such other division of benefits or other adjustments as would be equitable to both countries and would make the cooperative development feasible" (Krutilla, 1966, p. 83). Hence, the second proposal would divide the *gross* benefits of cooperative development.

The treaty adopted this second proposal (Krutilla, 1966, p. 70):

> "In exchange for the stream regulation provided by the Canadian storages, the United States agreed to share equally the increase in dependable capacity and average energy at United States head plants on the U.S. reaches of the Columbia downstream, and to advance payment in amount equal to one-half the estimated damage reduction in the flood plain of the lower Columbia."

Krutilla (1966) believes that the gross benefits formula leaves the United States worse off compared to the alternative of developing the Columbia river unilaterally. Why then would the U.S. agree to the terms of the treaty? Krutilla (1966, p. 96) offers an explanation:

> "Suppose that the Columbia Treaty is regarded not as an isolated affair between Canada and the United States in which the benefits to either party are tied to the outcome of the specific negotiations, but rather as one of many matters on which the two countries must

> come to mutual accommodation: in that event, it is not at all clear that the division of the nominal gains is inequitable. The vital interests of the United States were in no way affected in the Columbia matter. It was an area in which the United States could make an attractive arrangement in exchange for concessions perhaps involving North American continental defense or perhaps other areas in which the vital interests of the United States are at stake. Unless one knows all the elements of the broader background, therefore, one cannot properly judge the equity of the Columbia Treaty terms."

## 2.2 The Indus Waters Treaty

Conflict over the use and distribution of the waters of the Indus basin dates back to the beginning of the 19th century. But, as these were intranational conflicts, they could be resolved by the central government (Kirmani, 1990, p. 201):

> "[The] first major dispute was resolved in 1935 through arbitration by the Anderson Commission appointed by the central government. As the demand for irrigation water increased, a new dispute emerged and it was again resolved in 1942 by a new commission (the Rao Commission) appointed by the central government. The procedures followed to resolve the disputes on both occasions were similar. The central government had the responsibility and authority to settle disputes between the provinces; it appointed commissions comprising representatives of the provinces and chaired by a neutral expert to arbitrate; the commissions were given the powers to decide the issues if the parties failed to agree; the decisions of the commissions were final and binding; and the provinces succeeded in managing conflicts by following this system."

When the Indian subcontinent was partitioned in 1947, the Indus basin, including an irrigation system, was divided between India and Pakistan. The waters feeding Pakistan's irrigation supplies were on the Indian side of the border, and in 1948 India diverted these waters away from Pakistan. Although the canals feeding Pakistan's irrigation system were eventually reopened, conflict between the two countries continued as India claimed sovereign rights over the waters passing through its territory. Pakistan proposed to settle the conflict through arbitration, but India refused. The dispute threatened war.

The World Bank then offered to help resolve the dispute, and both India and Pakistan agreed. Negotiations between the three parties began in 1952. At first the World Bank emphasized the advantages of joint use and development of the Indus basin managed as a single water resource. Concerns over sovereignty, however, made this proposal unacceptable. In 1954, the World Bank changed tack, and proposed dividing the Indus and its tributaries. India was offered the three eastern rivers (Ravi, Beas and Sutlej), while Pakistan was offered the three western rivers (Indus, Jhelum and Chenab). Canals were to be constructed to divert waters from the western rivers to replace Pakistan's irrigation supplies from the eastern rivers. Construction of these was to be paid by India. Once these canals had been constructed, waters from the eastern rivers would cease to flow to Pakistan.

Pakistan believed that the western rivers would not adequately replace the country's historic use of the eastern rivers, and studies by both Pakistan and the World Bank confirmed that storage dams would also have to be constructed on the western rivers to ensure an adequte supply. The World Bank then amended its orginal proposal to include storage dams in the project to replace Pakistan's use of the eastern rivers. The cost of contructing both the link canals and the storage dams, however, was high, and India refused to pay; it argued that the dams were not needed and that its liability should be based on the Bank's original proposal.

The Bank responded to this new stalemate with external financing for the replacement works (supplied by Australia, Canada, Germany, New Zealand, the United Kingdom, Italy and the United States). This was enough to resolve the dispute, and in September 1960 India and Pakistan signed the Indus Waters Treaty. The treaty prescribed that construction of the replacement works in Pakistan should be completed within 10 years, and this was in fact achieved.

In addition to resolving this dispute, the treaty includes provisions for managing potential future disputes. The treaty establishes a permanent Indus Commission, made up of one commissioner from each country. The commission is required to meet regularly to discuss potential disputes as well as cooperative arrangements for the development of the basin. Either party must notify the other of plans to construct any engineering works which would affect the other party, and provide data to the other party about such works. If a dispute cannot be resolved by the commission, then the matter may be taken up by intergovernmental negotiations or, failing these, arbitration.

Yet, in the 30 years since the treaty was signed, neither party has proposed a joint project for development of the basin. Controversy has arisen over the design and construction of facilities on both sides of the basin. Some disputes have been resolved; others are pending. Still, the treaty may have been successful (Kirmani, 1990, p. 202):

> "It is almost three decades since the treaty was signed, but both India and Pakistan have implemented its provisions faithfully. They made remarkable progress in developing the water resources allocated to them and achieved self-sufficiency in food production. The Indus Waters Treaty is one of the most remarkable examples of a treaty that led to successful management of conflicts between sovereign riparian countries of a large river basin and served to promote development and prosperity in both countries."

**2.3 Convention on the Protection of the Rhine Against Pollution by Chlorides**

The Rhine basin passes through the territory of nine countries. The main stem of the river, extending from Lake Constance in Germany to the outflow of the river into the North Sea in the Netherlands, passes through just four countries--the above two plus France and Switzerland.

The International Commission for the Protection of the Rhine Against Pollution was established in 1950. Its tenure was to be limited, but the 1963 Berne Convention established a permanent

basis for the Commission. The Commission has no real authority, but it does coordinate the collection of water quality data along the river and makes recommendations to member states regarding environmental quality. However, these recommnedations require the unanimous agreement by all parties (originally, parties to the Convention included the above four countries plus Luxembourg; in 1979 the agreement was amended, and the European Economic Community became a signatory). Because of its lack of authority and the unanimity rule, the Commission was unable to have any real effect on its own.

The Rhine suffers from pollution of many types, salt pollution being one of the most serious. Although salt does not pose serious problems for human health, in high concentrations, salt can cause damage to agriculture. In the early 1970s, salt concentrations at the Dutch-German border often exceeded 300 mg/l. It was at this time that international negotiations were convened to examine the control of salt emissions into the Rhine.

At the time, there was one major polluter: a potash mine in France known as Les Mines de Potasse d'Alsace. The mine actually emitted about 40% of salt entering the Rhine, but control of emissions from other industrial sources was "...considered to be virtually impossible" (LeMarquand, 1977, p 104). Hence, negotiations centered on reducing emissions from the French potash mine. The problem for negotiation was to decide by how much emissions from the French mine were to be reduced, and how the costs of effecting those reductions were to be shared by the four riparians.

In 1972, a Conference of the Ministers on the Pollution of the Rhine agreed to limit the concentration of chloride ions at the Dutch frontier to 200 mg/l. To meet this objective, emissions from the French mine were to be reduced by 60 kg/sec beginning in 1975. These emissions were to be stored deep underground.

The cost of underground storage was originally estimated to be about 100 million francs, and the four riparians agreed to divide this cost as follows: France and Germany would each pay 30% of the cost, the Netherlands would pay 34%, and Switzerland would pay 6%.

After this agreement in principle was reached, a new study on the project estimated that the costs of the project could be up to five times more expensive than originally estimated. France proposed that the original cost sharing formula be extended to cover this much greater cost, plus inflation and any contingency in the event of cost overruns. At this point negotiations stalled and entered a period of deadlock. Finally, in 1976, an agreement was reached to reduce emissions from the French mine by just 20 kg/sec at a cost of 132 million francs. This cost was to be shared according to the same percentages negotiated four years earlier.

This agreement--known as the Convention on the Protection of the Rhine Against Pollution by Chlorides--acknowledged the earlier negotiated target of a maximimum chloride ion content of 200 mg/l at the German-Netherlands border, and the earlier target of reducing emissions at the French mine by 60 kg/sec. The agreement stipulated that this target was to be "achieved gradually." The agreement was very specific on the initial 20 kg/sec reduction, but said

that"...after consideration of the results obtained during the initial stage...[the French Government will] take all steps necessary to achieve before January 1, 1980 the objective...[of reducing emissions by at least 60 kg/s], by injection into the Alsatian sub-soil or by other means, subject to an agreement on the technical terms and conditions of the project and on the financing of the costs relating thereto." In fact, the agreement did not come into force until 1985, due to delays by France (Birnie and Boyle, 1992, p. 244).

Despite these difficulties, the Rhine Chlorides Convention is important insofar as it serves as an example for sharing the costs of pollution control among all the riparians, rather than imposing these on the polluters alone or on the victims (beneficiaries) alone.

The primary beneficiary of the agreement is the Netherlands, and this country also pays the largest share of the costs of pollution abatement. Since Dutch emissions do not affect the other riparians, this would appear to be an example of the "victim pays principle." However, France and Germany bear a large share of the cost of abatement, even though they are not affected by the concentration of salts in the Rhine. France and Germany agreed to contribute toward the total cost for reasons of "equity" (LeMarquand, 1977). Furthermore, Switzerland, the state farthest upstream, agreed to contribute toward the cost of abatement, even though it would not benefit directly. The Swiss contribution was based on the principle of "solidarity," defined by the OECD Principles on Transfrontier Pollution as seeking "...as far as possible an equitable balance of rights and obligations as regards the zones concerned by transfrontier pollution." LeMarquand (1977, p. 119) argues that this position reflects the playing of a possible reciprocal and repeated game: "No doubt [the Swiss] also feel that solidarity on this issue could be advantageous to them on other subsequent issues."

## 3. Theory

### 3.1 Unidirectional Externalities

Suppose an upstream country, labelled U, inflicts damage on its downstream neighbor, D. To be more precise, assume that U emits a pollutant into the shared river. (It is not essential that the externality be transmitted through a pollutant; the example could just as well be the extraction of water or the silting of a river. What is essential to the discussion which follows is that the externality is unidirectional.) U can abate its pollution at a cost C(Q) (marginal cost C'(Q)), where Q is the level of abatement. This abatement yields D a benefit B(Q) (marginal benefit B'(Q)).

To work through a solution to this problem, we need to specify the rules of the game. One such rule may be supplied by international law, and that concerns the *status quo* point of negotiations. Absent a cooperative agreement, what outcome should we expect to observe?

The law of international water resources offers two extreme rules relating to property rights (see Caponera, 1983). The doctrine of *unlimited territorial sovereignty* states that a country has exclusive rights to the use of waters within its territory. This means that a country may pollute

its rivers as much as it wants. This view, sometimes called the Harmon Doctrine, was forcefully expressed by the Attorney General of the United States, M. Harmon, in 1895, when commenting on Mexico's claim to water originating north of the border:

> "...the fundamental principle of international law is the absolute sovereignty of every Nation as against all others within its own territory... all exceptions, therefore, to the power of a Nation within its own territory must be traced up to the consent of the Nation itself. They can flow from no other legitimate source."[7]

In contrast, the doctrine of *unlimited territorial integrity* states that the quantity and quality of water available to a country cannot be altered by another country. This rule implies that the upstream country cannot pollute the shared river.

Now, these two doctrines clearly imply very different pre-bargaining positions. If the doctrine of unlimited territorial sovereignty is accepted by both parties, and if each party seeks to maximize its own payoff, then the upstream country will ignore the damages from pollution downstream. To maximize its *own* payoff, the upstream country will abate its emissions up to the point where the marginal cost of abatement equals the marginal benefit of abatement to itself. In an extreme example, where the upstream country does not benefit at all from abatement, no abatement will be undertaken in the absence of bargaining, even if the downstream country would benefit substantially from upstream abatement. Under the doctrine of unlimited territorial integrity, the pre-bargaining position is very different. The upstream country cannot emit any pollution into the river, even if the downstream country would not suffer any damage from pollution. Whichever doctrine is accepted, provided pollution upstream causes damage downstream and provided abatement is costly, the pre-bargaining outcome is likely to be inefficient. Both parties could potentially be made better off though bargaining.

### 3.2 The Coase Theorem

One might expect that two such different doctrines would result in two different post-bargaining outcomes. However, Coase's (1960) famous "theorem" shows that this is not the case if (see Mäler, 1990): (i) both countries know the functions C and B; (ii) there are no transactions costs; (iii) the pollution of the river can be seen in isolation from other international relations; and (v) the functions C and B are independent of the legal doctrine employed (i.e., there are no income effects).

To see this, consider Figure 2. If the doctrine of unlimited territorial sovereignty is applied, U has no obligation to abate any of its emissions. However, that does not mean that no abatement will be undertaken. The *status quo* point for negotiation is the 0 intercept. At this point, the benefit to D of abating one unit of emission is higher than the cost to U of undertaking that

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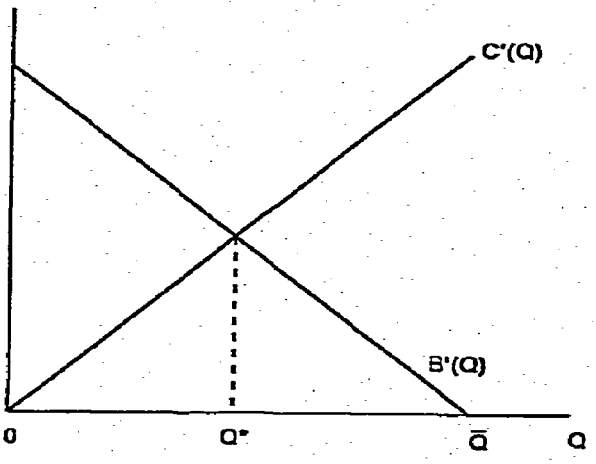
[7]The quote is taken from Caponera (1980), p. 7.

FIGURE 2




abatement. Indeed, incrementally this holds true up to $Q^*$. Hence, D should be willing to pay U a greater amount than D would be willing to accept to abate its emissions up to $Q^*$. Bargaining may therefore yield gains from trade. If the doctrine of unlimited territorial integrity is accepted, then U cannot pollute the river without D's approval. Let us suppose that pollution is eliminated when abatement is $\overline{Q}$. Then the *status quo* point for negotiation is $\overline{Q}$. But at this level of abatement, the marginal cost of abatement to U exceeds the marginal benefit to D. Clearly, U would have an incentive to pay D for the privelege of polluting the river by one unit, and D would have an incentive to accept such a payment. Exchange should continue until all gains from trade had been exploited--that is, until $Q^*$ had been reached. This is of course precisely the same level of abatement which the two parties would agree on under the alternative legal doctrine. It is also the level of abatement which maximizes joint net benefits; i.e., aggregate net benefits can be no higher than $B(Q^*) - C(Q^*)$. In contrast to the pre-bargaining outcomes, the post-bargaining outcome is efficient.

According to the Coase Theorem, the bargaining problem is not one of determining $Q^*$ but of determining how the gains to cooperation should be shared between the two parties. The sharing of the gains is the topic of cooperative game theory and is discussed later in this section. Determining the magnitude of those gains does, however, depend on the legal doctrine that is accepted by both parties, as discussed below.

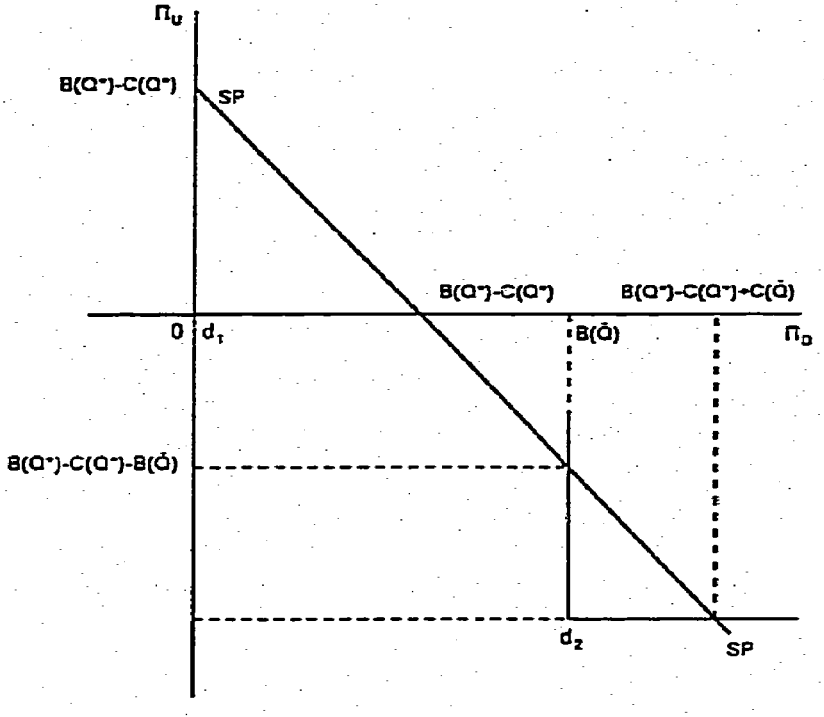
### 3.3 Determining the gains to cooperation

The gain to cooperation is the difference in the aggregate payoff between the noncooperative and full cooperative outcomes. The noncooperative outcome is the outcome which would result in the absence of bargaining. The full cooperative outcome is that which maximizes the aggregate payoff. In the case of the prisoners' dilemma game shown in Figure 1a, the gain is $(5 + 5) - (3 + 3) = 4$.

The gains to cooperation must be calculated relative to the outcome where U and D do not cooperate, and as we have seen this outcome depends on the legal doctrine that is accepted by the two parties. Under the doctrine of unlimited territorial sovereignty, U receives net benefits $\pi_U = - C(0) = 0$, and D receives net benefits $\pi_D = B(0) = 0$, if negotiations fail. Hence, the *status quo* or disagreement point in this case is (0, 0), which is labelled $d_1$ in Figure 3. Under the doctrine of unlimited territorial integrity, $\pi_U = - C(\bar{Q})$ and $\pi_D = B(\bar{Q})$ if negotiations fail. The *status quo* or disagreement point for this case is labelled $d_2$ in Figure 3.

If both countries cooperate fully, aggregate net benefits will be $B(Q^*) - C(Q^*)$. Assuming that side payments are permitted, these aggregate net benefits can be shared in a number of ways. The curve labelled SP in Figure 3, which has a slope of -1, shows how these net benefits can be shared.

Figure 3




The gain in net benefits depends on $B(Q^*) - C(Q^*)$ and the disagreement point, which is itself determined by the accepted property rights regime. In the case of unlimited territorial sovereignty, the gains are given by the vertical distance between the SP line as it hits the y axis and $d_1$. In the case of unlimited territorial integrity, the gain is given by the vertical distance between the SP line and the disagreement point $d_2$. For the case shown in Figure 3, the gain is smaller in this latter case.

For the example given in Figure 3, it is plainly in the interest of U to claim the doctrine of unlimited territorial sovereignty, for the worst payoff for U under this doctrine is 0, whereas the best payoff for U under the alternative doctrine of unlimited territorial integrity is $B(Q^*) - C(Q^*) - B(\overline{Q}) < 0$. Similarly, it is in the interest of D to claim the alternative doctrine, because the best payoff for D under the doctrine of unlimited territorial sovereignty, $B(Q^*) - C(Q^*)$ is less than the worst payoff for D under the doctrine of unlimited territorial integrity, $B(\overline{Q})$.

### 3.4 The Coase Theorem in an international context

While elegant and illuminating, there are a number of problems with the Coase theorem in an international context. Most importantly, there does not exist a third party which can impose either doctrine on the two countries. Agreements between parties must be self-enforcing (see Barrett, 1990). But if that is true, then why should D accept the first doctrine or U the second? The doctrine which is most attractive to one country is least attractive to the other. As Caponera (1983, p. 178) notes, "In the present world, application of the two doctrines mentioned would breed permanent conflict."

Further, it is misleading to view the problem in isolation of other matters, a point which is made by all three case studies in Section 2. If a country accepts a doctrine in one instance, then the precedent may be held against it in another. As an example, if U were downstream from a country Z, then U may not wish to support the doctrine of unlimited territorial sovereignty against D for fear that the same doctrine will be turned against U by Z. One can also imagine the example of a country U which is upstream, but also *downwind*, of D. The doctrine which may spare U the costs of water pollution control may also impose upon U the obligation to pay D for the costs of air pollution control. Hence, it may not be in the self-interest of either party to endorse unreservedly one of the doctrines.

Related to this point, Mäler (1990, pp. 86-87) notes that countries are typically involved in a web of international relations:

> "Two countries with a transboundary pollution problem will have a large number of links other than the flow of pollutants from one of the countries to the other.... One country may want to make concessions in order to improve friendly neighbourhood relations and thereby achieve advantages in other areas of mutual interest."

We have already seen the importance of international relations generally to negotiated settlements in the case of the Columbia River Treaty. In this case, the agreement over sharing the benefits of development of the Columbia River seemed to have been linked to other border issues.

In the case of the Indus Waters Treaty, bad relations between India and Pakistan actually dictated that joint development of the waters for joint gain be ruled out.

A dispute between the United States and Mexico provides another example of linkage.[8] In the 1960s, the concentration of salt in the waters of the Colorado River increased dramatically on the Mexican side due to the drainage into this river from the Wellton-Mohawk Irrigation Project, just across the border in Arizona. Technically, the United States could have ignored Mexico's request to remedy the problem--that at least was the view of the State Department. This is because the 1944 Water Treaty between Mexico and the United States did not mention water quality explicitly, and stated that Mexico would have to accept its share of water under the treaty "from any and all sources," including, potentially, drainage. However, the State Department believed that the United States would suffer in other ways if it pressed its case. First, the United States wanted to maintain good relations with Mexico for the resolution of *other* cross-border issues--including illegal immigration, drugs trafficking, and trade. While it might suit the United States to ignore Mexico's plight in this one case, another case would be bound to arise where the United States would suffer from activities south of the border. Second, if the United States argued the legal doctrine of unlimited territorial sovereignty in this case, and ignored Mexico's claims, then countries other than Mexico might wish to argue the same doctrine to the disadvantage of the United States in some other case.

As the above example demonstrates, while the United States may have laid claim to the Harmon doctrine in 1895, it has not itself stuck by this claim. Indeed, not long after Harmon claimed the United States' right to absolute sovereingty over the use of the Rio Grande, the United States engaged in negotiations with Mexico leading to the 1906 Convention concerning the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes. Similarly, while India once claimed "full freedom...to draw off such waters as it needed" from the Indus, the subsequently negotiated Indus Water Treaty (see Section 3) effects an equitable apportionment of the waters.[9]

The problem with the two polar doctrines, as the above example illustrates, is that neither is likely to be acceptable to *both* parties. Suppose U invokes the doctrine of unlimited territorial sovereignty in negotiations. Then D might well threaten to reconsider its position on trade or defense agreements between the two countries. Likewise, if D invokes the doctrine of unlimited territorial integrity, then U might well threaten to pollute the river anyway.

### 3.5 Rational Threats

In many cases, the disagreement point for negotiations will not be decided by legal doctrines alone but by the threats that countries can make regarding the actions they would choose in the event that negotiations break down. In some cases, this disagreement point will be given by the noncooperative outcome. However, in general, a country will do better in negotiations if it can commit itself to a particular action in the event of a break down in negotiations. Such strategic behavior can enhance the country's strength at the negotiating table.

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[8]For a discussion of this case, see LeMarquand (1977).

[9]Birnie and Boyle (1992), p. 219.

As an example of threats which may alter the strengths of different parties in negotiations, consider the continuing negotiations between Turkey and Syria over border security and the shared waters of the Euphrates. In the run-up to negotiations in January 1993, Turkey announced plans to start irrigating along the Harran plain from May, diverting more water from the Ataturk reservoir, upon which Syria relies for hydro-electricity production. Syria has sought to link negotiations over water to security, since Turkey relies on Syria to curb rebels of the Kurdish Workers' Party (Murray-Brown, 1993). Threats by both parties may be seen as a prelude to a negotiated settlement over both security and the use of the Euphrates.

To understand the significance of such threats, consider the following simple example, illustrated in Figure 4a. Two countries are negotiating over the construction of a water project. Each country has a binary choice: it can build a project on its side of the border or not build. The outcome which maximizes collective net benefits is where country A builds the project on its territory, and B does not build. This outcome yields A net benefits of $1, and B net benefits of $9.

## Figure 4

**(a) Disagreement Game**

| | | Country B: Build | Country B: Don't |
|---|---|---|---|
| Country A | Build | 3,-5 | 1,9 |
| | Don't | 2,0 | -1,1 |

This game has a unique equilibrium. If A chooses to build, B's best response is to not build. If A chooses not to build, B's best response is again not to build. Given that B will not build whatever A does, A's best response is to build. Hence, A will build the project and B will not. Since this outcome will result even if negotiations fail, the outcome represents the equilibrium disagreement point for negotiations. Since aggregate net benefits cannot be increased by choosing some alternative set of actions, bargaining is likely to result in both parties receiving their disagreement point payoffs, (1,9).

This game is not very interesting insofar as both players choose to do what is in their collective interest (i.e., the outcome is efficient, in contrast to the prisoners' dilemma). However, suppose that both countries could commit to undertaking a particular action in the event that a negotiated solution could not be reached. Then Country A might be able to improve its negotiated settlement if it could commit to not building the project on its side of the border if negotiations failed. Such a commitment would not alter the aggregate of payoffs but it would alter the distribution of payoffs.

We know that the negotiated settlement will involve A building the project and B not building, because this outcome maximizes joint net benefits. The real problem for negotiation is how the gain to cooperation should be divided. The gain is calculated relative to the disagreement point. Given that this is a two player game, it is plausible to assume that this gain will be divided evenly between the two parties. (This happens to be the Nash bargaining solution with transferable utility. It is also the negotiated outcome suggested by the theory of focal points; see below.)

Associated with the above disagreement game is a threat game. In the threat game, each player commits to a particular action in the event that negotiations fail. The payoff each party receives is calculated by subtracting the total payoffs to both parties under the disagreement point from the maximum joint payoff (10). If both countries build, aggregate net benefits are -$2. Compared with this disagreement point, a negotiated outcome can increase net benefits by $10 - (-$2), or $12. Dividing these gains equally, Country A would receive a payoff of $3 + $6, or $9, and country B a payoff of -$5 + $6, or $1. In other words, if both countries can commit to build in the event that negotiations fail, the negotiated outcome will require that A build and B not build, and that B transfer $8 to A, such that the payoffs now equal (9,1).

**Figure 4**

**(b) Threat Game**

| | | Country B: Build | Country B: Don't |
|---|---|---|---|
| Country A | Build | 9,1 | 1,9 |
| | Don't | 6,4 | 4,6 |

To determine which threat each country would want to make, we need to calculate the payoffs associated with all feasible choices. These are shown in the threat game in Figure 4b. As it happens, the equilibrium to this game is not that both countries build. It is instead that neither country builds. Given this disagreement point, the equilibrium negotiated outcome with rational threats involves A building and B not building, and B transferring $3 to A. The equilibrium payoffs are then (4,6).

Now, in this example, threats pose no problem for efficiency; they only serve to change the distribution of the gains from cooperation. However, the fact that countries could gain in making such threats credible suggests that they may be willing to use up resources toward this end. In other words, in attempting to improve their negotiating positions, countries may eat up some of the potential gains from cooperation.

The game depicted in Figure 4 is based loosely on the Columbia River case. In this case, joint net benefits are maximized by the construction of water storage facilities on the Canadian side of the Columbia River. If these facilities were not constructed, then the United States might build facilities south of the border, but these would be less efficient. The United States believed that Canada would want to develop the Columbia River on its side of the border anyway, and so felt that it did not need to compensate Canada much for constructing the project. The Nash equilibrium to this game therefore involves Canada constructing the project, and the United States receiving a large portion of the benefits without having to make a side payment to Canada.

However, later in negotiations British Columbia threatened to construct an alternative project and to abandon development of the Columbia River. This alternative to a negotiated settlement would harm the United States, and hence put British Columbia in a strong negotiating position. As it happens, this threat by British Columbia was perceived by the United States to be credible, and it is for that reason that British Columbia was able to secure a more attractive settlement in the 1961 treaty.

### 3.6 Bargaining with more than 2 countries

Bargaining can be quite different when there are three countries than when there are two. Table 1 indicates that there are about 50 river basins that are shared by three or more countries, and so our analysis of bargaining should be extended.

Consider the following game.[10] There are three countries, and each has one ton of hazardous waste to dispose of. Each country receives a payoff of -n for every n tons disposed of in its own territory. The waste must be disposed of in the territories of the three countries. Since the aggregate payoff to all three countries is the same, irrespective of the final distribution of waste, the game is zero sum. That is, every allocation of waste is a Pareto optimal allocation.

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[10]See Shubik (1987, pp. 541-2).

Now, the rules of a game specify what it is that the players may do. Let us suppose that international law imposes the doctrine of unlimited territorial integrity upon all players. Then, no country can dispose of its waste in another country without that country's consent. Hence, the *status quo* is where each country retains its waste. Since the *status quo* is a Pareto optimal allocation, no reallocation would be preferred by the parties. In particular, no coalition of countries could secure a higher payoff for itself by departing from the initial allocation; the initial allocation is thus a unique *core* allocation.

Let us now suppose that international law imposes upon all players the doctrine of unlimited territorial sovereignty. Then countries have the right to dump their waste wherever they choose. Any coalition of two countries can guarantee itself an aggregate payoff of -1 by dumping its two tons of waste in the third country and accepting that the third country will dump its waste in one of the two countries forming the coalition. Let us suppose that countries 1 and 2 form the coalition and decide to share their aggregate payoff of -1 equally. Then the payoffs are (-.5, -.5, -2). But country 3 can offer to strike a deal with country 2 which would make 2 better off, such as the allocation (-2, -.25, -.75). However, countries 1 and 3 can dominate this proposal with (-.5, -2, -.5). And so on. In other words, the set of core allocations in this example is empty; under the doctrine of unlimited territorial sovereignty, a bargaining outcome (based on the core) does not exist.

This example points to another problem with the Coase Theorem, for it demonstrates that the existence of a bargaining outcome (based on the theory of the core) does depend on the assignment of property rights.[11] Under one regime, the game has a unique core allocation--the initial allocation. Under the other regime, the core does not exist.

Now, I have assumed here that one of the doctrines is *imposed* on the three countries, and yet we know that there does not exist a third party which can impose a doctrine on countries. For this example, however, there is only one allocation which, intuitively, would seem to be acceptable to all of the parties, and that is the allocation (-1, -1, -1). This allocation is a focal point, as it entails an equal division of the costs of waste disposal (see Section 3.8); that is, the allocation (-1, -1, -1) is in some obvious sense equitable.

The three parties might arrive at this outcome from a number of different directions. Most obviously, they might agree to accept the doctrine of unlimited territorial integrity. Suppose instead that the parties agree to the doctrine of unlimited territorial sovereignty. Then, negotiations will start from the allocation (-1, -1, -1). We know that any coalition of two countries can improve on this allocation under this doctrine. However, countries might choose not to deviate from this allocation, for each country would know that, whatever allocation it agrees to as part of a coalition, another coalition would inevitably be formed subsequently which might yield this country a lower payoff.

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[11]This point is made by Dasgupta and Mäler (1994).

Alternatively, the parties might wish to ignore the question of property rights altogether--one reason being that doctrines should apply in all situations, and as we have already seen, the doctrine that is most attractive to a country in one situation may not be attractive in another. Instead, the countries might agree to a principle which applies only in this game. For example, the parties might agree to the "proximity principle", which states that waste should be disposed of near to where it is generated. This results in the outcome (-1, -1, -1) without recourse to acceptance of a property rights regime. This is exactly how the members of the European Union have resolved their dispute about the disposal of hazardous waste.

In the above example, the core is either unique or empty, depending on how the rules of the game are specified. In other cases, the core may be very large. To see this, consider the following example. A river runs through 3 countries. It starts in country 1, and then flows through countries 2 and 3 in succession. Countries 1 and 2 each emit one unit of pollution into the river. This pollution harms only countries that are downstream. The pollution can be abated at a cost, and the level of abatement undertaken by player i is $x_i$, $1 \geq x_i \geq 0$. The payoffs are $\pi_1 = -1.5x_1$, $\pi_2 = x_1 - 0.5x_2$, $\pi_3 = x_1 + x_2$. This game, in contrast to the previous one, is a positive sum game.

Under the doctrine of unlimited territorial integrity, countries 1 and 2 must abate all of their pollution in the *status quo*. The outcome yields (-1.5, 0.5, 2). Since the full cooperative outcome does not yield a higher aggregate payoff, the core is unique and consists of the initial allocation. In this sense, this game is similar to the hazardous waste game.

Under the doctrine of unlimited territorial sovereignty, no abatement is undertaken (in the absence of side payments), and the payoffs ($\pi_1$, $\pi_2$, $\pi_3$) are (0, 0, 0). Under the full cooperative outcome, $x_1 = x_2 = 1$, and aggregate net benefits rise from 0 to 1. If players 1 and 2 cooperate on their own, they can do no better than to set $x_1 = x_2 = 0$, and so all three players receive a payoff of 0. If players 1 and 3 cooperate on their own, they can do no better than to set $x_1 = 0$. Similarly, player 2 can do no better than to set $x_2 = 0$; hence, all three players receive a payoff of 0. If players 2 and 3 cooperate on their own, they will set $x_2 = 1$. Player 1 can do no better than to set $x_1 = 0$. Hence, $\pi_1 = 0$, and $\pi_2 + \pi_3 = .5$.

The allocation (a, b, c) is in the core if $a, b, c \geq 0$, $b + c \geq .5$, and $a + b + c = 1$. Clearly many allocations satisfy these requirements, including (1/3, 1/3, 1/3), (.5, .5, 0), (0, .5, .5), and (.5, 0, .5). These allocations vary substantially. What allocation would players agree to accept? The core concept does not tell us, although there are other solution concepts in cooperative game theory that do have unique outcomes. For example, the Shapley values for this game are (.17, .42, .42), and these might be taken to be an arbitrated solution. This concept gives a greater payoff to players 2 and 3 because these players can secure a greater payoff by forming their own coalition than can player 1 in combination with either 2 or 3.

Of course, a doctrine cannot be imposed. What kind of outcome might the countries negotiate? Let us suppose that they wish to ignore committing to either doctrine. Now, the aggregate gains to cooperation are highest when $x_1 = x_2 = 1$, and so we should expect that these abatement

levels will be a part of the negotiated settlement. However, country 1 will almost certainly claim that it should be compensated in some way for undertaking the abatement; after all, country 1 is not required to do so under the doctrine of territorial sovereignty. One possible outcome is that the parties agree to split the difference between the allocations under the two doctrines, (-1.5, .5, 2) and, say, (.17, .42, .42). This results in the outcome (-.67, .46, 1.21). Under this outcome, country 1 receives partial compensation for undertaking abatement which benefits the other parties, while country 3 pays for a portion of the abatement undertaken by country 1. There is nothing compelling about this outcome except that it is a compromise between the two extremes, and in this sense may be seen to be equitable. The resolution to the Chlorides case, discussed in Section 2.3, is consistent with this outcome. Recall that in that case the outcome was efficient, and the upstream countries agreed to pay for a portion of the costs of reducing pollution on the basis of equity, where "equity" reflected "an equitable balance of rights and obligations."

### 3.7 The doctrine of reasonable and equitable use and development

In fact, the practice of international law has generally not allocated property rights to one party or the other, as the Coase Theorem suggests might be done, but has rather recognized an alternative doctrine: that of *equitable utilization* (see, e.g., Birnie and Doyle, 1992). As examples, the Permanent Court of International Justice, in the *River Oder* case, reasoned that there existed a community of interest in navigation among all riparian states, based on equality of rights over the whole navigable course of the river. The tribunal deciding the *Lac Lanoux* arbitration similarly recognized that though France could carry out water diversion works within its own territory, it nevertheless had an obligation to consult Spain, which shared the waters, and to safeguard Spain's rights to the watercourse.

The International Law Commission (ILC), set up by the United Nations to encourage "...the progressive development of international law and its codification," agreed the Helsinki Rules on the Uses of the Waters of International Rivers in 1966, and in Article IV stated that "Each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin." Similarly, Article 5 of the ILC's 1991 draft report states:

> "1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal utilization thereof and benefits therefrom consistent with adequate protection of the watercourse.
>
> "2. Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection an development thereof, as provided in the present articles."

What does "equitable and reasonable" mean? The ILC provides no clear guide, but it does list relevant factors to be taken into account, including:[12]

> "(a) geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;
>
> (b) the social and economic needs of the watercourse States concerned;
>
> (c) the effects of the use or uses of the watercourse in one watercourse State on other watercourse States;
>
> (d) existing and potential uses of the watercourse;
>
> (e) conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;
>
> (f) the availability of alternatives, of corresponding value, to a particular planned or existing use."

Part (f) recognizes that the negotiated outcome must reflect the opportunities which the countries have of acting unilaterally. Of course, it is this set of opportunities which determines the disagreement point for negotiations, and as we have seen countries have an incentive to influence this set of opportunities.

Related to this doctrine is another principle included in the International Law Commission's draft text. This principle states that "Watercourse states shall utilize an international watercourse in such a way as not to cause appreciable harm to other watercourse States." The qualifier "appreciable" would seem to distance this principle from that of unlimited territorial integrity. Article 21 discusses obligations in the context of pollution:

> "Watercourse States shall, individually or jointly, prevent, reduce and control pollution of an international watercourse that may cause appreciable harm to other watercourse States or to their environment, including harm to human health or safety, to the use of the waters for any beneficial purpose or to the living resources of the watercourse."

---

[12]Birnie and Boyle (1992) note that this list of factors provides nothing more than a guide to deciding how "equitable and reasonable" should be defined in any particular case.

In fact, few treaties prohibit pollution outright.[13] Most tolerate some pollution, and indeed "equitable utilization" is seen to include use of a watercourse for the disposal of pollutants. Where this principle runs into difficulty is in failing to define "appreciable harm."

### 3.8 Focal Points

There does not exist a complete, compelling theory which predicts how the gains to cooperation will be distributed. However, concerns for equity and reasonableness do loom large in the analysis of negotiated outcomes. Schelling's (1960) brilliant work on focal points argues that the "fair" or "reasonable" outcome as perceived by the public becomes the focus of negotiations, not because such an outcome is necessarily just but because this outcome is known by both parties, known to be known by both parties, etc. It is a point on which negotiations focus.

Imagine that two countries are negotiating over the construction of a joint project for irrigation. The gains to cooperation are understood by both parties to equal $100. One party might open negotiations by saying that it should get $99 and the other just $1. But the latter party would know that the former would get nothing if an agreement were not reached, and so knows that the 99-1 split is something from which the former country would be willing to retreat. Of course, the former country would know this as well, and so is unlikely to make the 99-1 offer to begin with. The only compelling division in this case is 50-50, and it is likely that this is the division to which the two parties will agree. In fact, equal division of the gains to cooperation has formed the basis for real negotiations. As an example, the Convention of 8 January 1927 between Turkey and the USSR states:

> "The two Contracting Parties shall have the use of one half of the water from the rivers, streams and springs which coincide with the frontier line between Turkey and the Union of Soviet Socialist Republics."[14]

Imagine now that the two parties also know that 75% of the river flows through one country and just 25% through the other. Then it is not obvious that the two parties would agree to split the gains to cooperation 50-50. They may instead decide on the 75-25 split. Alternatively, imagine that one country has twice the population of the other. Then it is possible that the negotiators might agree to allocate two thirds of the gain to the country with the larger population in order to equalize the gain per capita.

---

[13]Exceptions include the 1956 Czechoslovakia-USSR Frontier Agreement, the 1961 Polish-USSR Frontier Treaty, the 1964 Finland-USSR Agreement Concerning Frontier Watercourses, the 1971 Declaration on Water Resources by Argentina and Uruguay, and the 1971 Act of Santiago Covering Hydrologic Basins by Argentina and Chile. See Birnie and Boyle (1992), p. 225.

[14]See United Nations (1975), p. 46.

It is plain why the ILC list of factors might prove relevant to negotiations. One other factor which can influence negotiations is precedent. As an example, the Rhine Chlorides Convention discussed in Section 2 employs the exact same allocation for sharing the costs of pollution control as was agreed in 1972, even though the parameters of the problem changed by the time the Convention was negotiated in 1976 and entered into force in 1985.

### 3.9 Reciprocal Externalities

Reciprocal externalities arise where each country imposes externalities on all others which share the resource. Examples include extraction of water from, or pollution of, a shared lake or acquifer. Reciprocal externalities differ from unidirectional externalities in that there exists a direct means by which one party may punish or reward the others' behavior, though not necessarily substantially. Suppose all parties which share a resource negotiate a cooperative agreement. If a party to the agreement chooses to withdraw, the others may punish this party by increasing their pollution emissions or by increasing their rate of extraction. This threat of punishment, if credible, may deter this country from withdrawing. Similarly, if a country accedes to the agreement, the other parties may reward this behavior by increasing their pollution abatement or by reducing even further their level of abstraction. A promise to reward accession, if credible, may serve to increase the number of countries which cooperate.

What prevents reciprocal externalities from being entirely internalized is the requirement that such cooperative agreements be *self-enforcing*. In contrast to agreements which internalize intranational externalities, international agreements cannot be enforced by a third party or central authority. Instead, the agreement must include mechanisms which by themselves can sustain a cooperative agreement.

The nature and significance of self-enforcing international agreements have been analyzed in a number of papers (see, for example, Barrett 1994a, 1994b). The point to make here is that, in general, such agreements may improve upon the non-cooperative or anarchic outcome but may not be capable of mimicing the full cooperative outcome.

To see this, consider the following model in which the number of signatories to an agreement, the obligations of the signatories, and the actions of non-signatories are all determined endogenously. A shared water resource is being polluted by 5 identical countries. Each has a net benefit function which depends on its own abatement and aggregate abatement as follows:

$$\Pi_i = Q - q_i^2/2, \qquad (1)$$

where $\Pi_i$ is the ith country's net benefits, $q_i$ is i's abatement and Q is aggregate abatement (i.e., $Q = \Sigma_j q_j$, $j = 1,\ldots,5$).

Each non-signatory will choose a level of abatement which maximizes (1) but under the assumption that its abatement choice will not affect the choice made by other countries. Non-signatories therefore face a simple calculus problem, and the resulting abatement level for each non-signatory is $q_n = 1$. If there is no cooperation, each country abates one unit, $Q = 5$ and $\Pi_i = 4.5$.

Suppose, however, that x countries cooperate and choose abatement levels which maximize their collective net benefits,

$$\Sigma_x \Pi_s(x) = x\,[xq_s + (5-x)] - xq_s^2/2 \qquad (2)$$

where $\Pi_s$ is the net benefit received by each signatory and $q_s$ is the level of pollution abated by each signatory. The value of $q_s$ which maximizes (2) is $q_s = x$. Given x signatories, each earns

$$\Pi_s(x) = x^2 + (5-x) - x^2/2 \qquad (3)$$

Each non-signatory earns

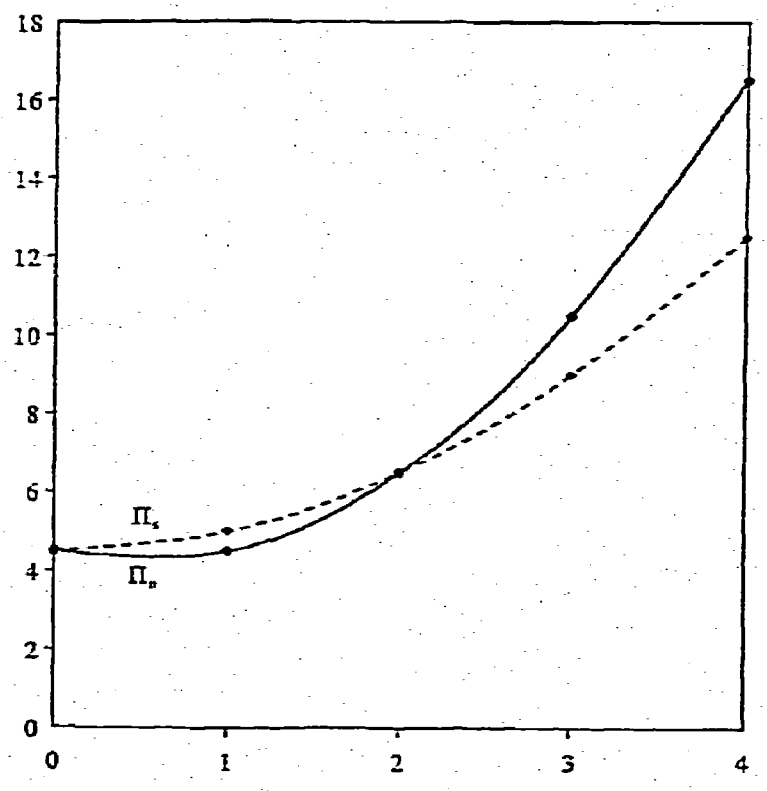
$$\Pi_n(x) = x^2 + (5-x) - 1/2. \qquad (4)$$

Equations (3) and (4) are shown in Figure 5. It is easy to prove, and this is reflected in the figure, that the self-enforcing IEA consists of 3 countries. Each signatory receives a payoff of $\Pi_s(3) = 6.50$, and each non-signatory receives a payoff of $\Pi_n(3) = 10.50$. Non-signatories receive a higher payoff because they free-ride. However, no signatory has an incentive to withdraw from the agreement. Further, no non-signatory has an incentive to accede to the agreement. The agreement consisting of 3 signatories, each undertaking 3 units of abatement, is therefore self-enforcing.

However, the cooperative agreement is incomplete; two countries cannot be induced to join. Furthermore, aggregate abatement and net benefits are 11 and 40.5, respectively, under the self-enforcing agreement but 25 and 62.5 under the full cooperative outcome.

What limits the ability of countries to sustain a better self-enforcing agreement is the mechanism for free-rider deterrence in this model. Signatories reward countries which accede to the agreement by increasing their abatement, and punish countries which withdraw from the agreement by decreasing their abatement. These rewards and punishments are, of course, credible (if they were not, the agreement would not be self-enforcing). However, they are too

FIGURE 5




small to sustain the full cooperative outcome. Alternative models may be able to improve on this outcome. For example, if the game of choosing abatement levels were played repeatedly (and infinitely often), then the full cooperative outcome might be sustainable provided the number of countries sharing the resource is not too large (see Barrett, 1994a). In general, however, self-enforcement means that full cooperative outcomes are not always sustainable.

### 3.10 Economies of Scale

Consider now a case where the provision of a public good exhibits economies of scale. Examples might be the abatement of pollution dumped into a shared water resource and flood control. Suppose that two countries can produce two units of the public good for $2 per unit, but that individually each country can produce a single unit of the public good for $3 per unit. Each unit, however produced, yields a benefit of $2.5 to each country. Figure 6 describes the game.

Figure 6

| | | B: Produce | B: Don't |
|---|---|---|---|
| A | Produce | 3,3 | -0.5,2.5 |
| | Don't | 2.5,-0.5 | 0,0 |

There are two pure strategy equilibria to this game: (produce, produce) and (don't, don't). If B does not produce the good, A's best reply is not to produce the good. Likewise, if A does not produce the good, then B will not produce the good. Yet, if A or B do produce the good, then the other country's best response is also to produce the good.

While both of these outcomes are equilibria, if the two parties can *communicate*, then they will agree to produce the good jointly. This is because both countries prefer this outcome to the alternative of (don't, don't). Unlike the famous prisoners' dilemma game, which depicts the provision of public goods in the absence of economies of scale, both parties can sustain the jointly preferred outcome because it is an equilibrium. All the parties need to do is coordinate their choice of actions.

## 4. Concluding Remarks

Water is a scarce resource, and is often not confined within territorial boundaries. These two observations suggest that conflicts may arise over the use of shared water resources. When such boundaries lie within the borders of a federal state, the conflict may be peacefully and efficiently resolved. As an example, the United States Constitution allows for the continued use of "compacts" or agreements between states, which had been employed during colonial times, subject to Congressional consent. However, disputes concerning such agreements can be taken to the Supreme Court, and the court's decision can be enforced by the federal government. Indeed, the federal government may itself impose an allocation upon states if they fail to reach agreement themselves.[15]

---

[15]See Muys (1976). The Boulder Canyon Project Act of 1928 conferred upon the Secretary of the Interior the authority to apportion the waters of the Colorado River at Hoover Dam and below among the three affected states, California, Arizona and Nevada, in the event that the three states could not agree to a tristate compact.

International water resources are different insofar as no third party has the authority to enforce an agreement among nation states, let alone to impose an agreement. Such agreements must be self-enforcing.

The celebrated Coase Theorem states that, however property rights are assigned, the final allocation of resources will be efficient. This desirable outcome is also alleged not to require government intervention. We have seen, however, that this intrepretation is wrong. Government intervention is needed to assign the property rights and to enforce them. Since there is no third party which can play this role in international relations, we cannot simply rely upon the Coase Theorem to allocate international water resources efficiently. However, nor can we rely upon the alternative of centralized resource allocation for, as stated above, there does not exist a World Government.

The background of international relations is thus one of anarchy, but precisely because a nation can improve its well-being by avoiding conflict and by coordinating its actions with others, there exist incentives to create institutions which can sustain cooperation. Anarchy need not mean mayhem. Indeed, efficient outcomes may emerge, as we saw in Section 3.10. However, efficient outcomes are not guaranteed, as we saw in Section 3.9. In the former case, the interests of countries were consonant; both countries were better off coordinating their actions and, having done so, neither had an incentive to deviate from the agreement. In the latter case, all parties were better off whey they cooperated fully but, having done so, all faced some incentive to deviate from the agreement. The self-enforcing agreement--the agreement which does not leave any incentives for deviations--may improve upon the outcome where cooperation is absent, but it may not maximize aggregate well-being of affected countries.

While the Coase Theorem is principally concerned with efficiency, equity is also of great concern in international water agreements. The reason is that a negotiated settlement, apart from expanding the aggregate of payoffs, also determines the distribution of this expansion. The allocation of resources is something which must be agreed by the different parties; as already noted, it cannot be imposed. One might say that polluters have a *de facto* right to pollute. But such a right is not only rejected by downstream states which suffer but also by the polluters themselves. This is partly because these countries will themselves be downstream or downwind of some other country and partly because nations interact on many other issues. As we have seen repeatedly, the analysis of international water agreements must be seen against the background of international relations generally. International law may well give emphasis to the doctrine of "equitable utilization" of water resources, but there is no clear definition of what this implies. In the Colorado River case, the polluter, the United States, agreed to pay for all of the costs of providing the downstream neighbor, Mexico, with clean water. In contrast, in the Rhine River case, the downstream country, the Netherlands, agreed to pay part--but not all--of the costs of clean up. In the case of the Columbia River Treaty, each party agreed to incur the costs of the project which related to construction on its side of the border, and to share evenly the gross benefits of the project, rather than to divide the *net* benefits evenly. This division may well have yielded the United States a smaller net benefit compared to unilateral development, and yet the United States still ratified the treaty.

Importantly, we have seen that negotiated outcomes need not maximize aggregate net benefits for all affected countries. To some extent, inefficiencies can be traced to the desire to nationalize resources rather than to gain from cooperative development. The Indus Waters Treaty is an outstanding example of this. The Indus Waters Treaty divided the Indus and its tributaries between India and Pakistan, rather than exploiting joint use and development of the basin as a single resource. However, the agreement was successful in preventing armed conflict between the two parties, and so we must be careful here in defining "efficiency." Furthermore, as we have seen, self-enforcing agreements may not be capable in all cases of maximizing aggregate net benefits.

Agreements for managing international water resources must consider the efficiency and equity aspects jointly. An example of this is the management of Nile water resources. The 1959 Nile Waters Agreement between Egypt and Sudan did not reserve any water for upstream riparians--notably, Ethiopia. Ethiopia has not claimed any rights to a portion of Nile waters, but such a claim is inevitable. During the 1980s, Egypt did not run short of water only because Sudan did not take its full allocation under the Nile Waters Agreement and because Ethiopia did not withdraw any water from the basin. Eventually, increased water demand will create a tension between these states.

Whittington and McClelland (1992) argue that a basin-wide approach could improve the efficiency of the use of Nile waters and yield benefits to all three riparians. Construction of a series of dams in Ethiopia would provide that country with irrigation but also yield additional benefits: elimination of the annual Nile flood, which would benefit both Ethiopia and Sudan; an increase in water storage upstream in Ethiopia, which would reduce losses due to evaporation, and hence increase the total volume of water available--Whittington and McClelland (1992) believe by the same amount as would be required by proposed irrigation projects in Ethiopia; and an increase in water storage, which would benefit Sudan's irrigation program and reduce siltation at the Roseires Reservoir in Sudan. Negotiations over the use of the Nile should proceed by demonstrating the net benefits associated with basin-wide management, and then identifying how these gains can be equitably shared by the three riparians.

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