Revisiting the potential for benefit sharing in the management of trans-boundary rivers

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Abstract

It has been suggested that trans-boundary water conflicts may be resolved through benefit sharing. The idea of benefit sharing is that a zero-sum game of water sharing is replaced through a positive-sum game of benefit sharing. In order to test the benefit sharing hypothesis, this paper presents a conceptual analysis of the incentives and institutional prerequisites required to realize mutual benefits in the use of trans-boundary rivers.

The paper argues that it is useful to distinguish negative and positive unidirectional externality problems related to the use of trans-boundary rivers, as these two cases represent fundamentally different cooperation problems. In the case of negative externalities, the benefits of cooperation exist in principle, but their realization requires an agreement on often disputed property rights as well as on the set up of an enforcement mechanism. Thus cooperation remains institutionally demanding. In contrast, in the case of positive externality problems, no property rights issues are involved. However, whether cooperation can be expected depends on the underlying payoff structure. The downstream riparian can be expected to participate in the provision of a positive externality upstream, either if the project is only collectively rational (coordination problem) or if the downstream riparian's participation allows for a Pareto improvement *vis-à-vis* the non-cooperative solution (cooperation problem). Given the property rights implications of negative externality problems, it may be useful, where possible, to refocus from negative to positive externality problems.

Keywords: Benefit sharing; Benefits of cooperation; Enforcement; Negative and positive unidirectional externalities; Property rights; Trans-boundary rivers

1. Introduction

In recent years a discourse on conflict and cooperation in the management of trans-boundary rivers has evolved (Gleick, 1993; Rogers, 1993; Barrett, 1994b; Waterbury, 1994; Bernauer, 1997; Wolf, 1998; Marty, 2001; Zeitoun & Warner, 2006). In this context some authors have suggested that international trans-boundary water conflicts may be resolved through benefit sharing (in particular Sadoff & Grey, 2002, 2005). The main idea of the concept of benefit sharing is that riparian states should not seek to

share the water itself, but instead share various benefits from the water. It is argued that by refocusing from the sharing of water (quantities) to the sharing of benefits from the water, a zero-sum game of water sharing is being replaced by a positive sum game of benefit sharing (e.g. Biswas, 1999; Sadoff & Grey, 2002; Klaphake, 2005). For instance, Sadoff & Grey (2002: 396) argue: "Focusing on the benefits derived from the use of water in a river basin, rather than the physical water itself, is another way to broaden the perspective of basin planners". In a recent publication they point out: "To negotiate the management and development of international shared rivers, riparians can focus their negotiations on the allocation of water rights or on the distribution of benefits derived from the use of water" (Sadoff & Grey, 2005: 422). Thus, according to this interpretation, the sharing of rights and the sharing of benefits can be understood as alternative negotiation strategies.

The discourse on benefit sharing presupposes that there are indeed benefits of cooperation in the use of trans-boundary rivers that can be realized and shared. In this context, Sadoff & Grey (2002) distinguish benefits from the river, to the river and beyond the river, as well as reduced costs because of the river. The idea is that cooperation can be driven by direct benefits from various water uses, by joint concerns for environmental protection, by a broader interest in regional integration or by the will to reduce the costs of conflict. However, if for the time being, we only focus on potential benefits from the river—which is at the core of the concept of benefit sharing—it is still not clear under which conditions it is in the interest of upstream and downstream countries to cooperate. Thus, it is also still not clear how mutual benefits can be realized and eventually shared. If the upstream country can realize benefits from the river for itself, why should these benefits be shared with downstream and vice-versa? And how can the downstream country induce the upstream country to cooperate?

This paper argues that there is still a need to develop a better understanding of the potential and the conditions for the realization of mutual benefits in the management of trans-boundary rivers. Therefore the paper will revisit the incentives encouraging upstream and downstream riparians to cooperate, taking different water uses and water-related infrastructure measures into account. In doing so, it will take an economic rational choice perspective which analyzes the conditions under which cooperation can be explained on the basis of rational self-interested behavior. More specifically, it will draw upon the economic theory of external effects and non-cooperative game theory.

In line with the literature (e.g. Rogers, 1993; Marty, 2001) the paper will argue that it is useful to distinguish negative and positive unidirectional externality problems in the use of trans-boundary rivers. Going beyond the literature, it will show how the incentives and the institutional prerequisites for cooperation, such as the need to define property rights and to set up enforcement mechanisms, differ for these two types of problems. As such the paper will show that these two cases represent fundamentally different cooperation problems. One implication is that, strictly speaking, the negotiation of water rights and the negotiation of benefits cannot be considered as alternative negotiation strategies. Whereas in the case of negative externalities both rights and benefits need to be addressed, in the case positive externalities, no property rights issues are involved in the first place. A policy implication is that, where possible, it may be useful to refocus from negative to positive unidirectional externality problems.

Section 2 will conceptualize trans-boundary water conflicts as negative and positive externality problems. Sections 3 and 4 will analyze the conditions under which cooperation can be expected for negative and positive externality problems respectively. Section 5 will summarize the findings. Section 6 will provide conclusions and Section 7 an outlook.

2. Trans-boundary water conflicts as externality problems[1]

From an economic perspective trans-boundary water problems can be conceptualized as unidirectional externality problems. An externality is present whenever the production or consumption activities of one economic agent have direct, non-price-mediated effects on the production or consumption activities of another economic agent (Mas-Colell *et al.*, 1995: 352). The externality is unidirectional if the affected parties cannot reciprocate the externality in the *same* use. This is typically the case in the use of trans-boundary rivers[2].

Furthermore depending on the underlying water use, these externalities may be negative or positive (see also Rogers, 1993; Bernauer, 1997; Marty, 2001). Table 1 distinguishes different water uses and water-related infrastructure measures and assesses their physical effects on different functions of the water resource system, which eventually affect other resource users. These different functions include the capacity of the resource system to provide a certain water quantity at a certain quality, the regulatory capacity of the resource system and its capacity to maintain water-related eco-systems.

In terms of water uses, the most visible effects are the negative effects of water abstraction on water quantity and of wastewater discharge on water quality. However, as Table 1 indicates, many uses that are usually considered as non-consumptive, such as hydropower generation, navigation or recreation may still have negative repercussions on ecosystem functions. Externalities may also stem from indirect water uses such as changes in land use (e.g. changes in forest covers), many of which affect water quality or the

Table 1. Effects of water uses and infrastructure measures on water resource functions.

	Effect on Water quantity	Water quality	Water regulation	Ecology
Water use/resource appropriation				
Water abstraction	−			(−)
Wastewater discharge	(+)	−		−
Hydropower generation				−
Navigation				−
Recreational uses				−
Fisheries				−
Consumption of forests, wetlands & flood plains		−	−	−
Infrastructure measures/provision of services				
Water supply systems	−			(−)
Wastewater treatment		+		+
Erection of dams	(+)	(−)	+/−	−
River channeling			+/−	−
Erection of dykes			−	−
Provision of retention areas	(+)	(+)	+	+
Ecosystem protection		+	+	+

Notes: + indicates positive effect; − indicates negative effect; () indicates minor effect. *Source*: Dombrowsky (2007: 48), adapted.

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[1] The analyses in Sections 2 to 4 build upon and take further material presented in a book publication by the author (Dombrowsky, 2007).
[2] Note that externalities tend to be more reciprocal in the use of border rivers or shared lakes.

regulatory functions of the system. With the exception of water quantity effects associated with wastewater discharge, the effects of water uses—or the appropriation of resource units—tend to be negative.

In contrast the provision of water infrastructure for a particular user or community may have positive or negative trans-boundary effects. Wastewater treatment that benefits the population of state A, also benefits the population of downstream state B. The erection of dams for hydropower generation will often have positive regulatory effects downstream, but may have negative effects on ecosystems. While the erection of dykes brings benefits for the population behind the dyke, it tends to increase the velocity of the flow and flood risks downstream, thus generating negative externalities downstream. In contrast the provision of retention areas for the benefit of community A, also has positive regulatory effects for downstream communities. Note that water quality problems represent combined negative and positive externality problems, where a negative externality is mitigated by the provision of a positive externality.

These examples show that the use of water goes along not only with negative externalities, but that water-related infrastructure measures may in some cases also entail positive external effects. Therefore, in the following, the conditions under which cooperation can be expected will be analyzed for negative and positive externality problems respectively.

## 3. Analysis of negative unidirectional externality problems

Negative unidirectional externalities typically occur if a water resource is appropriated by an upstream riparian, leading to negative effects for downstream riparians. For instance, Israel's diversion of water from the upper Jordan through the National Water Carrier has significantly reduced the water available for the Jordanians and Palestinians downstream. Thus, Israel's diversion has given rise to demands for a greater allocation to the downstream riparians, both in the planning stage of the carrier in the 1950s and later during the negotiation of water issues in peace talks in the 1990s (e.g. Dombrowsky, 2003).

In principle, negative externalities problems may be analyzed on the basis of the Coase theorem as illustrated in Figure 1 and a general case shall be analyzed below (Coase, 1960; Barrett, 1994b; Feess, 1998).

Let us assume that upstream country A abstracts water from a river restricting development opportunities in downstream country B. Let q be A's level of water abstraction leading to negative external effects. We may assume that A's marginal benefits (MB) decrease with an increasing level of abstraction. In the absence of international coordination, A can be expected to extend its abstraction until marginal benefits are zero (q_{max}). We may furthermore assume that the marginal costs (MC) to B increase with A's level of abstraction and that an abstraction level of q_{max} will entail marginal costs to B in the order of MC_{max}.

Under these circumstances it can be argued that it is in the interest of B to offer a side payment to A so that A reduces its level of abstraction, as this allows the parties to capture gains of cooperation. The gains of cooperation are maximized if A reduces its level of abstraction to the Pareto efficient quantity of abstraction q_p. q_p is defined by the intersection of the MB and the MC curves P, with P indicating the Pareto optimum. In this case B would offer a side payment of the size of the area $q_{max}Pq_p$ and the benefits of cooperation would amount to the size of the area $MC_{max}Pq_{max}$. To be clear, this arrangement presupposes that both parties (and in particular B) accept the right of A to use the water (the "*laissez-faire*" rule) as the starting point for negotiations. It is furthermore assumed that both parties have all the relevant information on cost and benefit functions and that they reach an agreement on the distribution of the benefits of cooperation.

More generally, according to the Coase theorem, negative unidirectional externalities may be internalized through voluntary bilateral negotiations if (1) property rights are well defined and (2) if
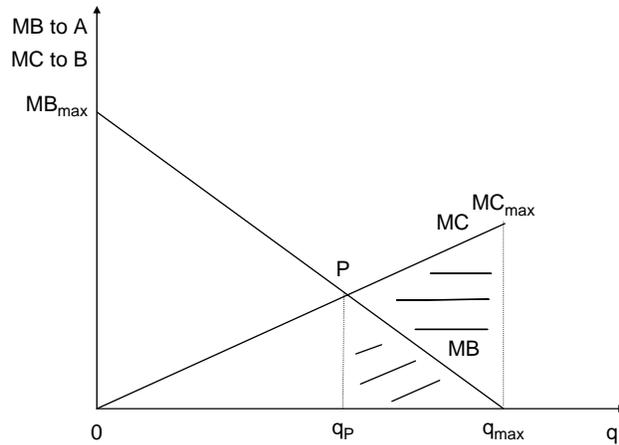
Source: Dombrowsky (2007: 126).

Fig. 1. Pareto efficient internalization of externalities.

transaction costs are sufficiently low (Coase, 1960). Property rights are well defined if either the *laissez-faire* or the liability rule (see below) holds. Transaction costs include information, bargaining, monitoring and enforcement costs. The Coase theorem provides the perhaps counter-intuitive insight that even in the case of negative externalities potential gains of cooperation exist, in principle.

However, in the international system we are faced with the problem that the assumptions underlying the Coase theorem typically do not hold. The reason is that there is no external authority which could define property rights to water. Instead, property rights can only be defined in a process of claim and counter-claim among the negotiating parties and the outcome of such bargaining is uncertain. Furthermore, international water negotiations can be expected to entail significant transaction costs. First, we are typically dealing with problems of imperfect information. Second, we may expect lengthy bargaining over the distribution of the benefits of cooperation. And third, there is no monitoring and enforcing authority. Furthermore, often international water problems involve more than two parties, as 87 of 263 international river basins worldwide are shared by three and more riparian countries (Wolf *et al.*, 1999). This again may raise transaction costs. This, however, implies that the negotiating parties have to address all these issues if benefits of cooperation are to be realized. In the following sections, two of these issues, namely the property rights and the enforcement problem, which represent distinguishing features between negative and positive externality problems, will be analyzed in greater detail.

3.1. The problem of undefined property rights

As mentioned above, in the context of international waters there is no external authority that would define property rights to water. According to Coase (1960) property rights would be well defined if either the *laissez-faire* rule or the liability rule applied. The *laissez-faire* rule says that all rights are with the party causing the externality. The liability rule says that all rights are with the damaged party. In international water law the equivalent to the *laissez-faire* is the doctrine of absolute territorial sovereignty and the equivalent to the liability rule is the doctrine of absolute territorial integrity. The doctrine of absolute

territorial sovereignty maintains that a watercourse state enjoys exclusive authority over the waters of an international watercourse within its territory. The doctrine of absolute territorial integrity says that the downstream state has a right to the natural flow of the water into its territory (McCaffrey, 2003a).

However, international law rejects both the doctrine of absolute territorial sovereignty and the doctrine of absolute territorial integrity as "factually myopic and legally 'anarchic'" (McCaffrey, 2003a: 135). Instead, it is argued that states should apply the doctrine of limited territorial sovereignty. The doctrine of limited territorial sovereignty says that the right to use an international watercourse is limited by the rights of other riparian countries to use the watercourse. According to McCaffrey (2003a: 138– 147) this doctrine is also reflected in the vast majority of international water agreements. It is furthermore underpinned by the principle of equitable and reasonable utilization of the 1966 Helsinki Rules and the 1997 UN Convention on the Law of the Non-navigational Uses of International Watercourses. However, an equitable utilization can not be determined unilaterally, but only through a process of claim and counter-claim by the parties involved, by balancing factors that are relevant in a given case (McCaffrey, 2003a: 339–345).

This implies that it may be difficult to reach an agreement for distributional reasons. The upstream riparian (or the riparian which appropriates the resource first) may not want to forego its *de facto* uses. The downstream riparian (or the riparian that wishes to appropriate the resource later), on the other hand, may reject the *status quo* as the starting point for negotiations for moral and strategic reasons. From a moral point of view, the downstream party B may question the legitimacy of the *status quo* on the basis of international law. From a strategic point of view, B would even be better off if property rights were reallocated first. Furthermore, offering a side payment may also be associated with the establishment of a reputation as a weak negotiator and the anticipation of side payments may provide incentives for strategic behavior by the upstream party A, in order to extract larger side payments (Mäler, 1990). If rights were reallocated, any gains to B would imply a loss to A. At the same time, any agreement on property rights would offer the potential for an efficient use of the resource and thus for the realization of gains of cooperation.

To be clear, the absence of an external authority that could define property rights to international waters implies that riparian countries have basically two alternatives if they want to realize gains of cooperation. They can recognize the *status quo* as the starting point for negotiations. This is equivalent to an explicit or implicit allocation of property rights according to the theory of absolute territorial sovereignty—which, however, is rejected by international law. Or they have to negotiate both, property rights and efficiency gains, either simultaneously or consecutively (see also Barrett, 1996). However, while the potential gains of cooperation may serve as an incentive to reach an agreement on property rights, these benefits of cooperation may not offset the losses to the riparian which appropriated the resource first from a reallocation of property rights. Given that property rights are *de jure* not specified, there is no way around an explicit or implicit recognition or negotiation of property rights (see also Richards & Singh, 2001).

Hence three different classes of negotiation outcomes are conceivable:

(1) The *status quo* and the theory of absolute territorial sovereignty are accepted as the starting point for negotiations. In this case we may expect an agreement on the basis of a side payment. This outcome can be expected to be efficient, but it would not necessarily be fair under the standards of international law. As an alternative to side payment, an agreement may also be reached on the basis of issue linkage, which functions as an in-kind side payment. This would have the advantage that it could avoid the loss of face associated with a side payment. Neither alternative would, however, resolve the underlying property rights issue.

(2) Downstream country B rejects the theory of absolute territorial sovereignty as a starting point for negotiations because of strategic or moral reasons, while upstream country A insists on it. In this case no agreement can be expected. The outcome would be neither efficient (*vis-à-vis* the *status quo*) nor fair.

(3) Both parties accept the theory of limited territorial sovereignty and reach an agreement on limited property rights and on sharing of the gains of cooperation. In this case the outcome is potentially efficient and fair. However, the implication may be that the party which appropriated the resource first may be worse off compared with the *status quo*. Hence, this outcome would be morally induced and cannot be explained on the basis of (narrow) rational self-interested behavior alone[3].

The above considerations show that the negotiation outcome cannot be predicted on the basis of rational self-interested behavior alone.

3.2. The enforcement problem

Given that in the international system there is no external authority that could enforce international agreements, an international agreement must be self-enforcing (Barrett, 1994a). The enforcement problem can be illustrated on the basis of a game–theoretic reconstruction of the above negotiation problem as illustrated in Table 2.

Let us again assume that upstream country A is withdrawing water from the river and that downstream country B is suffering from water shortage. In this case, A has the option to share the water or not. B has the option to make a side payment or not. For the sake of illustration let us assume that both parties accept the *status quo* and thus the theory of absolute territorial sovereignty as a starting point for negotiations. In this case we may assume, in line with the above assumptions on benefits and costs, that side payment and sharing of water is preferred over no side payment and no sharing of water for both players. The preference orders over the four different strategy combinations of the two players are illustrated in Table 2 with 4 indicating the most preferred and 1 indicating the least preferred outcome. In this case the game has the structure of a "prisoner's dilemma" game (Luce & Raiffa, 1957), but on the basis of a side payment (see also Bennett *et al.*, 1998)[4].

In this situation each player has an incentive to defect in the one-shot game, irrespective of what the other player does. Hence joint defection (no sharing—no side payment) is the dominant strategy and a Nash equilibrium is maintained[5]. At the same time both players would be better off if they jointly cooperated, but joint cooperation is a non-equilibrium outcome. The reason is that both players have the incentive to defect unilaterally from the cooperative outcome: A does not share, speculating on B's payment, irrespective of A's behavior. B does not pay, speculating on A's sharing, irrespective of a payment. In this case it is likely that the

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[3] Barrett (1996) argues that the move towards an equitable allocation is motivated by customary law and that the wish of countries to adhere to custom can be explained as equilibrium behavior that is in their self-interest. The reason is that a particular upstream–downstream constellation cannot be looked at in isolation from other matters. If a country adopts an extreme doctrine in one situation, this may set a precedent which can be held against it in another.

[4] If B rejects the theory of absolute territorial sovereignty, it can be shown that B plays a game of "deadlock" and overall the game has the structure of a "constant sum" game (Dombrowsky, 2007), in which gains by one party imply a loss by the other party. In this case no cooperation can be expected (see outcome 2 discussed above).

[5] An equilibrium is a Nash equilibrium if no player has an incentive to deviate from his strategy as long as the other player does not deviate.

Table 2. Upstream water withdrawal as prisoner's dilemma game with side payments.

		Downstream country B Side payment (C)	No side payment (D)
Upstream country A	Shares (C)	3, 3	1, 4
	Does not share (D)	4, 1	2, 2*

* Nash equilibrium.
Source: Dombrowsky (2007: 176).

two parties would not conclude the agreement in the first place. Thus, this game–theoretic reconstruction of the "side payment game" shows that while a side payment could realize efficiency gains, a side payment agreement is not self-enforcing unless there is an enforcement mechanism put into place.

In the case of side payment games, one possible enforcement mechanism is the introduction of a "policy of small steps". In a first step, a partial payment is made for partial sharing and payments and sharing are gradually increased over time on the condition that both sides cooperate. In this case, cooperation could be sustained as an equilibrium outcome.

The above analysis shows that even if an agreement is reached, in the case of negative externalities, it is not yet self-enforcing. Instead, it requires an enforcement mechanism to be set up, at least if rational self-interested behavior is assumed. This implies that riparian countries should take the enforcement problem into account in the design of treaties.

4. Analysis of positive unidirectional externality problems

In some cases upstream riparians provide positive externalities downstream through infrastructure measures that change the natural conditions of a river system. For instance, the Blue Nile is characterized by the annual Blue Nile floods. These are caused by the region's specific meteorological conditions and carry a high degree of silt loads caused by natural erosion processes. In this case, measures in Ethiopia which contribute towards retaining these natural floods and silt flows would have positive external effects for Sudan and Egypt downstream (e.g. Guariso & Whittington, 1987). A simplified case along these lines shall be examined in the following model.

Let us assume that a mountainous upstream country A and a flat downstream country B share a river. Downstream country B is affected by severe floods and considers options for improved flood control. At the same time, upstream country A seeks to develop its hydropower potential. Let us assume that the storage reservoir of the prospective upstream hydropower project would also contribute towards downstream flood control. Furthermore we will assume that country A is exclusively interested in hydropower generation, but has no need for flood control. Thus, country A will benefit from any hydropower generated and country B from any flood control realized. The question is thus: under which conditions can cooperation can be expected? More precisely: under which conditions would B have an interest in contributing towards the provision of the positive externality (public good) generated upstream. In the following, it will be shown that the incentives for B's participation depend on the respective payoff structure. Three different cases will be presented. In the first case, it is individually rational for upstream country A to carry out the project. In the second case, B's participation leads to a Pareto improvement for both parties. In the third case, the project is only collectively rational.

4.1. Case 1—The Project is individually rational for upstream

Let us first assume that there is one potential dam site, site a, in country A, with hydropower and flood control benefits and a positive rate of return for A. This situation is indicated in Table 3 as alternative a. Given that the dam entails positive net benefits for A, it is rational for A to go ahead with the project. In this case, A would realize a net benefit of 2. Downstream country B would do nothing and receive a flood control benefit of 0.5. If country A is aware of this positive externality, A might approach downstream country B and ask for a compensation for the provision of the public good. However, as long as country A goes ahead with the project anyway, country B has no incentive to contribute towards the provision of the positive externality generated upstream. B might only agree to do so for moral reasons. Thus, under the assumption of rational self-interested behavior, no cooperation can be expected under the assumptions of project a.

4.2. Case 2—Downstream participation leads to a Pareto improvement

Let us next assume that in addition to project alternative a there an alternative b within country A, with lower hydropower but higher flood control and higher aggregated benefits hydropower and flood control benefits than alternative a as indicated in Table 3 for alternative b. Furthermore, let us assume that only one project, either a or b, will be realized[6].

In the absence of cooperation, it would again be rational for country A to realize project a, as project a maximizes A's payoff. Downstream country B on the other hand would be better off if project b was realized, but as the project would be located within A's territory, B cannot unilaterally pursue this project. Given that project b represents a welfare improvement when compared with the unilateral solution, transition from project a to b allows for the realization of gains of cooperation. However, it would only be rational for upstream country A to engage in project b if this would not imply any loss *vis-à-vis* project alternative a. The respective loss would be compensated if B made a side payment of at least 0.5 to A (see solution 1 in Table 4)[7]. The side payment ensures that alternative b represents a Pareto improvement over alternative a, that is, that at least one player is made better off without making any player worse off. Obviously, such a side payment (or cost sharing arrangement) presupposes that a financial compensation for the loss of some of A's immediate hydropower benefits is acceptable to A.

Table 3. The dam game: payoffs under unilateral action by upstream country A.

Alternative	Costs to A	Hydropower benefits to A	Flood protection benefits to B	Net benefits to A	Net benefits to B	Aggregated benefits
a	2.0	3.0	0.5	1.0	0.5	1.5
b	2.0	2.5	1.5	0.5	1.5	2.0
c	2.0	1.5	2.0	−0.5	2.0	1.5

Source: author

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[6] Project alternative b may an alternative dam site or another way to operate dam a, i.e. by optimizing storage at the expense of hydropower generation.
[7] In this numeric example this would result in an equal sharing of the net benefits from the project.

Table 4. Case 2—joint dam b with different modes of benefit sharing.

Solution	Costs to A	Costs to B	Hydropower benefits to A	Flood protection benefits to B	Net benefits to A	Net benefits to B
1	1.5	0.5	2.5	1.5	1.0	1.0
2	1.25	0.75	2.5	1.5	1.25	0.75
3	1.0	1.0	2.5	1.5	1.5	0.5

1: Minimum side payment from B to A (*vis-à-vis* non-cooperative solution). 2: Equal sharing of gains of cooperation (*vis-à-vis* non-cooperative solution). 3: Maximum side-payment from B to A (*vis-à-vis* non-cooperative solution). *Source*: Own presentation.

However, it is likely that upstream country A would like to participate in the sharing of any benefits of cooperation. Thus the two countries would have to agree on a benefit sharing formula. The maximum side payment that B would make to A would be a side payment of 1 (see solution 3 in Table 4)[8]. In the given situation an obvious solution would be that the two countries share the gains of cooperation *vis-à-vis* the non-cooperative solution, equally, in which case A would receive a net benefit of 1.25 and b would receive a net benefit of 0.75 (see solution 2, Table 4).

As in the case of negative externalities, the question is whether a respective agreement would be self-enforcing or whether an enforcement mechanism would be required. In order to analyze the stability of the agreement, Table 5 shows the possible strategy combinations for the two players in a 2 × 2 matrix. It is assumed that upstream country A has the choice to cooperate by carrying out project b or to defect by carrying out project a. Downstream country B has the choice to cooperate by making a side payment of 0.75 or to defect by rejecting a side payment. In this case, joint defection is a dominant strategy and a Nash equilibrium ensues. At the same time, both players would be better off if they cooperated. This game–theoretical reconstruction shows that this particular problem represents a "prisoner's dilemma-type" situation. Thus, similar to a side payment game in the case of negative externalities, under this type of positive externality problem, cooperation also relies on setting up of an enforcement mechanism.

4.3. Case 3—the project is only collectively rational

The incentives for cooperation change again if the project only pays when both countries contribute towards its realization. Let us assume that there is only one project alternative c, as indicated in Table 4. In this case, it would not be rational for upstream country A to go ahead with the project unilaterally.

Table 5. Case 2—Joint dam b as prisoner's dilemma game with side payments.

		Downstream country B Side-payment (C)	No side-payment (D)
Upstream country A	Project b (C)	1.25, 0.75	0.5, 1.5
	Project a (D)	1.75, −0.25	1, 0.5*

*Nash equilibrium.
Source: author

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[8] In this numeric example this would result in an equal sharing of costs of the project.

Table 6. Case 3—joint dam c with different modes of benefit sharing.

Solution	Costs to A	Costs to B	Hydropower benefits to A	Flood protection benefits to B	Net benefits to A	Net benefits to B
1	1.5	0.5	1.5	2.0	0	1.5
2	0.75	1.25	1.5	2.0	0.75	0.75
3	0	2.0	1.5	2.0	1.5	0

1: Minimum payment from B to A to carry out the project. 2: Equal sharing of overall net benefits/gains of cooperation. 3: Maximum payment from B to A to carry out the project. *Source*: Own presentation.

However, if downstream country B participated in the provision of the project, the project could result in net benefits for both parties. In this case, it would only pay for country A to carry out the project if downstream country B made a payment of more than 0.5 (solution 1 in Table 6). The project would only pay for B if its payment was less than 2 (solution 3 in Table 6). If the gains of cooperation (or coordination) were to be shared equally, B would have to make a payment of 1.25 (solution 2 in Table 6).

The question is whether such an arrangement also requires an enforcement mechanism. The game–theoretical analysis of the player's strategy combinations for solution 2 is shown in Table 7. In this case both parties have the choice to cooperate by contributing towards project c or to defect by not contributing. The analysis of the payoff structure shows that there are two Nash equilibria, joint defection and joint cooperation, however, only the cooperative outcome is a Pareto optimum. The game therefore has the structure of an assurance game (see for instance Stein, 1982: 303). In contrast to the prisoner's dilemma, which represents a typical cooperation problem, the "assurance" game is a typical example of a coordination problem, which is characterized by more than one equilibrium outcome[9]. The problem is an "assurance" problem because it would only be rational to defect if there was uncertainty about the behavior of the other party (e.g. Barrett, 2003: 93). Once the parties involved agree and assure each other that they will pursue the Pareto-superior equilibrium outcome, the agreement is self-enforcing. The reason is that it is in the interest of both players to implement the agreement, as neither party can gain from unilateral defection. Thus, in this particular case of positive unidirectional externality problems, an agreement would be self-enforcing and no enforcement mechanism would be required[10].

5. Results

The above analysis shows that the incentives and the institutional prerequisites for cooperation in the use of international trans-boundary rivers depend on the specific problem structure at hand. In this context, it is useful to distinguish between negative and positive unidirectional externality problems.

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[9] Game theory distinguishes between cooperation and coordination problems (e.g. Stein, 1982; Barrett, 2003). Cooperation problems occur when independent decision making leads to equilibrium outcomes that are Pareto-deficient (e.g. the prisoner's dilemma). In contrast coordination problems are situations with more than one equilibrium outcome where actors have a common interest in avoiding a particular outcome.

[10] In Dombrowsky (2007), I argued that positive externality problems may take on the structure of a coordination problem, but I have now come to the conclusion that the specific numeric example provided in Dombrowsky (2007: 184) remained ambiguous. The case differentiation in this section qualifies my earlier statement by indicating under which conditions positive unidirectional externality problems may indeed take the structure of a coordination problem.

Table 7. Case 3—joint dam c as assurance game.

		Downstream country B Contributes (C)	Does not contribute (D)
Upstream country A	Contributes (C)	0.75, 0.75*	− 0.75, 0
	Does not contribute (D)	0, − 1.25	0, 0*

*Nash equilibrium.
Source: author

Table 8. Comparison of negative and positive unidirectional externality problems.

	Negative externalities	Positive externalities
Cooperation incentive	Yes, but	Depends
Cooperation dependent on:		
Agreement on property rights	Yes	No
Agreement on benefit sharing	Yes	Yes
Relevant information	Yes	Yes
Enforcement mechanism	Yes	Depends

Source: author

As summarized in Table 8, in the case of negative externality problems, incentives for cooperation exist in principle, but the question is whether the parties can reach an agreement on the underlying property rights. As long as the upstream riparian maintains a doctrine of absolute territorial sovereignty, the downstream party may question the legitimacy of the *status quo* as the starting point for negotiations on the basis of international law. The downstream riparian is in a dilemma situation: should the downstream riparian simply accept the *status quo*, despite the fact that a doctrine of absolute territorial sovereignty is rejected by international law and realize whatever benefits can be realized? Or can the downstream party morally induce the upstream riparian to reallocate property rights first? While the benefits of cooperation may serve as an incentive to reach an agreement on a reallocation property rights, overall these benefits of cooperation may not be high enough to offset the losses for the upstream party involved in a reallocation of rights.

Whether cooperation can be expected in the case of positive unidirectional externality problems depends on the underlying payoff structure. It is rational for a downstream riparian to participate in the upstream provision of a positive externality if it does not pay for the upstream party to carry out a respective measure unilaterally (coordination problem), or if there is an alterative to the upstream party's unilateral solution which makes the downstream party better off and increases overall welfare (cooperation problem). No cooperation can be expected if it is individually rational for the upstream party to implement the aspired project. Thus, broadly speaking, cooperation can be expected if the downstream party wishes to have a say in upstream project design and operation.

In terms of institutional prerequisites for cooperation, in both cases—where there are positive or where there are negative unidirectional externalities, cooperation relies on the resolution of information problems and on an agreement regarding the distribution of the gains of cooperation. The two cases differ, however, in the sense that only in the case of negative unidirectional externality problems is there a need to come to an agreement on property rights. The reason is that the provision of upstream infrastructure, entailing a positive externality downstream, does not imply a direct appropriation of water resources. The two cases also differ in terms of enforcement in the sense that

cooperation in the case of negative unidirectional externality problems will always need an enforcement mechanism if rational self-interested behavior is assumed. In the case of positive externalities, enforcement will only be needed if the problem has the structure of a prisoner's dilemma or cooperation problem. No sanctioning mechanism is needed if the situation has the structure of an assurance game or coordination problem.

It has been argued in the literature that overall cooperation is more likely in the case of positive than in the case of negative externality problems (e.g. Marty, 2001). The above analysis shows that if incentives for downstream participation exist, cooperation in the case of positive unidirectional externality problems is indeed institutionally less demanding than in the case of negative externality problems. However, no cooperation can be expected if it is rational for the upstream country to go ahead with the respective project on a unilateral basis. In this sense, Marty's (2001) prediction has to be qualified.

6. Conclusions

Overall, the above analysis confirms that an economic perspective on the (net) benefits of various water uses may be useful for the resolution of trans-boundary water conflicts, because it may—under certain conditions—help riparian countries to realize win–win situations. At the same time, the paper shows that at least in the case of negative unidirectional externality problems, the institutional prerequisites for realizing benefits of cooperation tend to be more demanding than usually explicated in the policy discourse on benefit sharing. In this case, there appears to be no way around the implicit or explicit recognition of the underlying property rights if mutual benefits are to be realized. This may often be difficult for distributional reasons. However, even in the case of positive unidirectional externality problems, whether or not downstream parties can be expected to participate in the upstream provision of positive externalities (public goods) depends on the situation. Therefore, it must be concluded that, on trans-boundary rivers, even with a benefit sharing perspective, cooperation remains demanding and cannot necessarily be expected.

The above analysis, furthermore, shows that from an analytical point of view, the negotiation of water rights on the one hand and of benefits on the other, strictly speaking, are not alternative negotiation strategies, as is sometimes suggested in the literature. In the case of positive externality problems, no property rights issues are involved and thus, property rights do not need to be negotiated in order for the benefits of cooperation or coordination to be realized. In the case of negative externality problems, the benefits of cooperation exist in principle, however an explicit or implicit recognition or negotiation of property rights is a necessary precondition for the realization of a benefit sharing scheme.

A policy implication of these findings is that it may in some cases be useful to shift the focus of negotiators from negative to positive externality problems in the same river system. This appears to be what Sadoff & Grey (2002, 2005) suggest implicitly when they propose to shift from water sharing to benefit sharing. It is also what appears to be happening in the Blue Nile Basin, where a shift has taken place from a focus on the sharing of water quantities to the exploration of joint multi-purpose projects that provide benefits to both upstream and downstream riparian countries[11]. While this is certainly a useful negotiation strategy, it presupposes that such a shift is possible, which may be the case in some

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[11] See http://ensap.nilebasin.org/index.php?option=com_content&task=view&id=44&Itemid=80 (accessed April 14, 2008).

basins but not necessarily in all. In particular it is difficult to conceive that it could contribute towards solving aggravated water scarcity problems, such as in the Jordan River Basin.

Thus, overall, it is hoped that the analytical perspective presented in this paper has contributed towards a better understanding of the potential and the limits of the concept of benefit sharing in the use of trans-boundary rivers.

7. Outlook

The purpose of this paper was to gain a better understanding of the potential and the prerequisites for the realization of mutual benefits in the management of trans-boundary rivers. Going beyond this paper, a number of comments are in order:

1. Additional theoretical work could help to explicate problems involved in the resolution of information problems and the bargaining on the distribution of the gains of cooperation, which need to be resolved in both negative and positive externality situations.
2. The paper has only looked at isolated problems in the use of trans-boundary rivers and the cooperation potential within that respective problem structure. Given that water is a multi-functional resource, there may be an opportunity to link complementary water uses (see Dombrowsky, 2007, chapter 6).
3. From an empirical point of view, it would principally be of interest to test the hypotheses generated. Initial comparative case studies by Marty (2001) suggest that positive externality problems tend to be easier to resolve than negative ones. A more systematic empirical test would require the characterization of problem structures in a larger number of international river basins, an analysis of the institutional arrangements and an examination of whether countries do or do not realize benefits of cooperation. Such an analysis would, however, be a major research effort on its own.
4. In procedural terms, the question arises whether an agreement on property rights must necessarily be a first step in a "cooperation" process, given the distributional issues involved. While it is certainly advisable to start a cooperation process with confidence building measures, the above analysis maintains that the mutual recognition of property rights is necessary as soon as benefits are to be realized in the case of negative externality problems. Nevertheless, more work is conceivable on the question of what we mean by a definition of property rights and how they should be specified. In this context, McCaffrey (2003b) advocates flexible approaches.
5. Finally, this paper's rational choice perspective highlighted the importance of enforcement in the case of cooperation problems. This notwithstanding, it is well known that enforcement mechanisms are generally rare in international relations and most countries comply with most agreements most of the time even in the absence of enforcement mechanisms (Chayes & Chayes, 1993). However, Downs *et al.* (1996) point to the fact that in many cases it may be easy for countries to comply, as many treaties do not ask their signatories to cooperate, but confirm the non-cooperative outcome. This raises the question of whether the latter observation also applies to international water treaties. If this is so, the current analysis could contribute towards improving existing treaties by indicating how it may be possible to realize a given cooperation potential. If, however, existing treaties do realize benefits without enforcement, this would call for a modification of the theory's underlying behavioral assumptions.

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