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**The Effect of Issue Linkage on Cooperation in Bilateral  
Conflicts: An Experimental Study with Relevance to  
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**by**

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# **The Effect of Issue Linkage on Cooperation in Bilateral Conflicts: An Experimental Study with Relevance to Transboundary Water**

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## **Abstract**

Environmental bilateral conflicts, such as in international environmental agreements, often involve more than one conflictive issue that requires solution. The theoretical literature suggests that linking issues of conflict open new opportunities for cooperation. We present a new experimental setting of bilateral conflicts, in which each issue is modeled as a different prisoner dilemma game. In two experiments, the effect of issue linkage on cooperation is evaluated by comparing a treatment in which the two games are played sequentially (isolated treatment) with one where they are played simultaneously (linked treatment). Specifically, in the linked treatment each agent observes the payoffs from playing the different paths across games (e.g., cooperate in game1 but defect in game2) and then act accordingly by committing to one of these paths. We differentiate the case where issue linkage implies symmetrical payoffs across games (Experiment 1), from the asymmetric case where one agent receives higher benefits from issue linkage (Experiment 2). The results reveal that issue linkage increase mutual cooperation and decrease mutual defection. We also find that asymmetry reduces the level of cooperation in both isolated and linked games, yet issue linkage facilitates higher cooperation rate even when the payoffs are asymmetric.

**Keywords:** Prisoner dilemma; issue linkage; asymmetric games; International Environmental Agreements; transboundary water.

## **1 Introduction**

Transboundary basins account for 60% of the world's river flow. There are 263 transboundary basins globally, of which 176 are bilateral and the rest are shared by three or more riparian states (Wolf et al. 1999). Transboundary water resources are often sources of conflict and tension, and their joint management among sovereign countries is often challenging. Each side has its own incentives for utilizing the resource, which are often in conflict with the incentives of the other side. The economic literature of transboundary river sharing (Barrett 1994; Dinar and Wolf 1994; Kilgour and Dinar 2001; Ambec and Sprumont 2002; Ambec, Dinar, and McKinney 2013) includes theoretical and sometimes empirical contributions regarding the circumstances in which riparians can attain cooperative outcomes in conflicts over water quantity sharing.

One of the complexities with transboundary water negotiations relates to the fact that they often involve multiple issues that require solution. Some issues might be equally important to both negotiating parties, while others might be much more important to one side than to the other. Negotiating over multiple issues increases the complexity of the negotiation process but may also provide additional opportunities to cooperate by 'issue linkage'. For example, in the case of international water negotiations linking between different issues could transform the negotiation from a gridlock to an agreement, such as in the case of the peace/water treaty between Jordan and Israel (Haddadin 2002). In cases of international rivers the issues could include water allocation, allocation of benefits or costs, regulation of cross boundary pollution, and decisions of joint development of the resource (Dinar et al. 2007). Several normative studies (Bennett, Ragland, and Yolles 1998; Just and Netanyahu 2000; Pham Do et al. 2012; Pham Do and Dinar 2014) show the usefulness of issue linkage in reaching a stable agreement.

Empirical testing of these propositions is challenging since it is impossible to experiment with problems of such stake in the real world. In this paper we suggest a complementary approach by developing a new experimental paradigm that involves negotiation over two conflictive issues, and test the effect of linking these issues on cooperation. The need to simplify the negotiation while using a laboratory approach might imply some loss of external validity, but it comes with the benefits of low implementation costs and high internal validity. As such, experiments are helpful in detecting influential factors that facilitate cooperation, and in gaining some first insights into how to handle these important problems.

To the best of our knowledge there has been no previous work that dealt with issue linkage in the laboratory. More broadly, the context of negotiations over multiple issues of conflict has been mostly overlooked by the experimental economics literature that has focused primarily on games characterized by a single issue of conflict/dilemma.

## **2 Can issue linkage help mitigate externalities in bilateral conflicts?**

As stated earlier, bilateral basins (i.e., two-player games) characterize most of the transboundary river basins in the world. The current study differs from earlier experiments on two-player games (Kagel and Roth 1995), by exploring a new setting in which parties face conflicts in more than a single issue. Viewing the negotiation of individual issues as games, linking two games can be advantageous since it opens an opportunity to exchange side payments and sustain self-enforceable agreements that facilitate credible threat against defection. Theoretical papers have supported this assertion (Folmer et al. 1993; Bennett et al. 1998) and have identified cases in which issue-linkage is expected to be advantageous (Just and Netanyahu 2000). Surprisingly, this assertion has yet to be studied experimentally.

The essence of the bilateral transboundary problems can be presented as a prisoner dilemma (PD) game. The upstream country chooses between sharing (cooperate) or not sharing (defect) water with the downstream. The downstream country chooses whether to make a side payment (cooperate) or not (defect) to the upstream country. The payoff structure of this game, which we outline in the next page (and Table 1), implies that the upstream country's dominant strategy is not to share, because sharing the water always costs it some welfare loss. The downstream country's dominant strategy is not to pay because making side payment always reduces its welfare. As the classic analysis of a PD game, the Nash equilibrium is not a socially optimal outcome. Both agents could receive higher payoffs if they would agree to cooperate.

The experiment presented in this paper is designed to test the simplest case of multi-issue negotiation: the bilateral case of two negotiating agents who decide on their strategies in two different issues. The main purpose of the study is to test whether the players respond to issue linkage by comparing their behavior by analyzing the payoffs when the issues are negotiated in isolation and when they are negotiated under linkage. Each issue is modeled as a Prisoner Dilemma (PD) game, which has a structure that characterizes many international conflicts

(Soroos 1994). A normal form of the general isolated games, and the general linked game, are presented in Tables 1 and 2, respectively.

Table 1 presents the normal form of the general isolated games. In each game the players choose between cooperate (C) and defect (D). The payoffs for each outcome of the game are represented by  $B_{jk}^i$  (first issue) and  $V_{jk}^i$  (second issue), with superscript  $i$  representing player  $i = 1, 2$ , and subscript  $j$  and  $k$  identifying the strategy played by the first and second players ( $c =$  cooperate,  $d =$  defect) respectively. The payoff structure of the first PD game is provided by  $B_{dc}^1 > B_{cc}^1 > B_{dd}^1 > B_{cd}^1$ , and  $B_{cd}^2 > B_{cc}^2 > B_{dd}^2 > B_{dc}^2$ , similarly for the second PD game:  $V_{dc}^1 > V_{cc}^1 > V_{dd}^1 > V_{cd}^1$ , and  $V_{cd}^2 > V_{cc}^2 > V_{dd}^2 > V_{dc}^2$ .

These conditions imply that the dominant strategy of each player is to defect, since cooperating would always cost her some welfare loss. Yet for the PD game such equilibrium is not the socially optimal outcome. Both agents could receive higher payoffs if they could agree to cooperate. Specifically, for the first game a partition function  $w^{PD1}$  can be obtained from Nash Equilibrium (NE), as follows:

$$(1) w^{PD1} = (i; [N]) = B_{dd}^i \text{ and } w^{PD1} = (N; \{N\}) = B_{cc}^1 + B_{cc}^2$$

Where  $N = \{1, 2\}$  is the finite set of players, and the structure that consists of the (grand) coalition is denoted by  $\{N\}$ . The same analysis applies for the second game given its identical structure to the first.

**Table 1:** Normal form presentation of the isolated games/issues.

Game/issue 1				Game/issue 2			
		Player 2				Player 2	
		C	D			C	D
Player	C	$B_{cc}^1, B_{cc}^2$	$B_{cd}^1, B_{cd}^2$	Player	C	$V_{cc}^1, V_{cc}^2$	$V_{cd}^1, V_{cd}^2$
1	D	$B_{dc}^1, B_{dc}^2$	$B_{dd}^1, B_{dd}^2$	1	D	$V_{dc}^1, V_{dc}^2$	$V_{dd}^1, V_{dd}^2$

Issue linkage refers to the situations where the two issues of conflict, modeled here as the two games, are not played successively (i.e., in isolation), but simultaneously. A normal form of the issue-linkage game is presented in Table 2. The game includes the same outcomes as the aggregated isolated PD games. The difference between this form and the isolated forms is that now these two games are combined. The players choose their strategy based on the entire space

of outcomes in the linked game, rather than consider each game separately. That is, each player chooses between cooperation in both games (*CC*), cooperation in the first but defection in the second or *vice versa* (*CD* and *DC* respectively), or defection in both games (*DD*). The main difference between the linked game and the aggregated isolated games is that the player's strategies need not be individually rational.

Issue linkage can be advantageous in cases where the linked games can generate outcomes that could not be obtained when the games are played in isolation. For example, in a case where the potential outcomes from game 1 are identical to the outcomes of game 2, the players share the same preferences for both games, no side payments exist, and thus linking these games does not yield a potential for an added benefit. However in the case where the payoff structure may yield reciprocal preferences across games (e.g., player 1 benefits more from cooperating in game 1 but player 2 benefits from cooperating in game 2), linking the issues may make it easier to reciprocate. In our experiment we examine such situation to test the degree to which players respond to opportunities from payoff linkage.

**Table 2:** Normal form presentation of the linked games/issues.<sup>1</sup>

		Player 2			
		CC	CD	DC	DD
Player 1	CC	$B_{cc}^1 + V_{cc}^1,$ $B_{cc}^2 + V_{cc}^2$	$B_{cc}^1 + V_{cd}^1,$ $B_{cc}^2 + V_{cd}^2$	$B_{cd}^1 + V_{cc}^1,$ $B_{cd}^2 + V_{cc}^2$	$B_{cd}^1 + V_{cd}^1,$ $B_{cd}^2 + V_{cd}^2$
	CD	$B_{cc}^1 + V_{dc}^1,$ $B_{cc}^2 + V_{dc}^2$	$B_{cc}^1 + V_{dd}^1,$ $B_{cc}^2 + V_{dd}^2$	$B_{cd}^1 + V_{dc}^1,$ $B_{cd}^2 + V_{dc}^2$	$B_{cd}^1 + V_{dd}^1,$ $B_{cd}^2 + V_{dd}^2$
	DC	$B_{dc}^1 + V_{cc}^1,$ $B_{dc}^2 + V_{cc}^2$	$B_{dc}^1 + V_{cd}^1,$ $B_{dc}^2 + V_{cd}^2$	$B_{dd}^1 + V_{cc}^1,$ $B_{dd}^2 + V_{cc}^2$	$B_{dd}^1 + V_{cd}^1,$ $B_{dd}^2 + V_{cd}^2$
	DD	$B_{dc}^1 + V_{dc}^1,$ $B_{dc}^2 + V_{dc}^2$	$B_{dc}^1 + V_{dd}^1,$ $B_{dc}^2 + V_{dd}^2$	$B_{dd}^1 + V_{dc}^1,$ $B_{dd}^2 + V_{dc}^2$	$B_{dd}^1 + V_{dd}^1,$ $B_{dd}^2 + V_{dd}^2$

<sup>1</sup> Notice that tables 1 and 2 suggest a general form that could be used for any 2x2 games, not only prisoner dilemma games. The nature of the game is defined by the relative payoffs that are implemented in the games.

## **Experimental studies on repeated prisoner dilemma**

The Prisoner dilemma game has been the target of extensive experimental research in economics (Kagel and Roth 1995), with over than 1000 experiments, most of which used iterated choices in a repeated game settings (Dawes 1980). A well-established finding is that initial cooperation rate is much higher than the theoretical equilibrium (which suggests no cooperation), yet cooperation breaks down towards the end of the repeated game (Andreoni and Miller 1993; Selten and Stoecker 1986). Most experiments study potential factors that affect cooperation within the game, either by the game structure and dynamics (e.g., whether payoffs are symmetric), and/or by the properties of the agents (e.g., gender, groups vs. individuals etc.). Almost all experiments have studied agents play within a single game, and most experiments employed a symmetric payoff structure in which the game payoffs were identical for both players.

While most experimental studies of PD have focused on symmetric games, in which the payoffs of both players are similar, few experiments have examined asymmetric PD games in which the game yields greater payoffs to one side than to the other. A consistent finding in the latter studies is that cooperation rate is lower in asymmetric games than in symmetric ones (Croson 1999; Beckenkamp, Hennig-Schmidt, and Maier-Rigaud 2007; Sheposh and Gallo 1973; Andreoni and Varian 1999).<sup>2</sup> Typically, the decreased cooperation rate is driven by the lower paid agents (Sheposh and Gallo 1973; Beckenkamp et al., 2007; Andreoni and Varian 1999), and it is typically attributed to fairness and equity concerns. All these experiments study a single game, very much like almost all the symmetric PD game experiments.

The current paper focuses on situations in which agents play two games, each of which is asymmetric. Therefore, each game in isolation is similar to the asymmetrical games described by the literature. However, since each game yields higher benefits to a different player, agents have the opportunity to compensate for such within-game asymmetries if they analyze both games holistically, by reciprocating when the games are played in isolation and cooperating when the games are linked. This holistic view opens a new interesting and unexplored question about the role of payoff symmetry across games. One possibility is that across games payoffs are symmetrical, as one game may be “mirror image” of the other in terms of the agents’ payoffs.

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<sup>2</sup> Schellenberg (1964) also studied the effect of asymmetry in PD games but used a setting in which the opponents actions were predetermined, and the game was played for course credit, not for real money.



The other possibility is that the payoffs from one game might be much higher than from the other game, so although one agent gets higher benefits from one game and the other gets higher benefits from the second one, agent might benefit more from issue/game linkage than the other one. That is, payoffs might remain asymmetric across games. In this paper we refer to both possibilities. Experiment 1 analyzes the situation of symmetric payoffs from issue linkage, and the second possibility of asymmetric payoffs from issue linkage in Experiment 2.

Experimental analysis of transboundary river basins conflicts is also scarce. An interesting exception is the experiment of Abbink et al. (Abbink, Moller, and O'Hara 2010). Abbink et al. addressed the trilateral conflict between Kyrgyzstan, Uzbekistan and Kazakhstan over the transboundary Syr Darya river, by running a laboratory three-person trust game that was tailored to model the main characteristics of this conflict. While the theoretical analysis of this situation reveals that regional cooperation is required for maximizing basin-wide net benefits, the experimental results reveal that the agents fail to set up mutually beneficial agreements (mainly in low water periods), consistently with past behavior in the actual water conflict. Abbink et al. (2010) demonstrate the value of a simple laboratory experiment to model the core aspects of real-world conflict in a simplified experimental game. They demonstrate that one approach of doing so is to mimic a specific real-world conflict by a tailored experiment to get insights of the core aspects of agents' behavior. We use a different approach by investigating a simplified structure that resembles core aspects of real world conflicts without tailoring it to a specific situation of interest. Our approach and Abbink et al.'s (2010) approach complement each other, and the use of each one is subject to the researcher's goals and objectives. Both approaches can be extremely useful for gaining insights into agent's behavioral regularities that are likely to emerge in such complex conflicts.

### **3 Experiment 1: The Effect of Linking Issues on Cooperation**

Our first experiment was designed to test the potential effect of issue linkage on cooperation, by comparing two experimental treatments. In treatment "Isolated" the subjects played two isolated prisoner dilemma games separately, each focusing on a different issue under conflict, one after the other, and were compensated based on their aggregated earnings from these two games. In treatment "Linked" the subjects played the linked game, comprised of the two isolated games, and were compensated based on their aggregated earnings from that game. In both treatments the

subjects payoffs is “symmetric” in the following sense: although in each issue the payoffs differ between players, player’s 1 payoffs from game 1 equals player 2’s payoffs from game 2 and vice versa.

At the beginning of the experimental session subjects received written instructions (Appendix A), which were also read aloud by the experimenter. Then subjects were randomly matched in pairs for the rest of the experiment (i.e., partner design). All games were played with the same partner for 30 consecutive trials, after each of which the players received feedback regarding the game outcome in that trial and their realized payoff. Subjects also received a full description of the games’ payoffs at the beginning of each new game. The experiment was programmed with zTree (Fischbacher 2007).

Seventy eight students participated in the experiment: 36 subjects were assigned to the “isolated” treatment and 42 subjects were assigned to the “linked” treatment. Subjects played the games in 30 consecutive trials. The exact payoffs from each action in one game were (in Israeli Shekels: ILS 3.5 = \$US1) were:  $B_{cc}^1 = 20, B_{cc}^2 = 11, B_{dc}^1 = 25, B_{dc}^2 = 0, B_{cd}^1 = 0, B_{cd}^2 = 15$ , and  $B_{dd}^1 = 10, B_{dd}^2 = 10$ . The payoffs of the second game were mirror image of the first (e.g.,  $V_{cc}^1 = 11, V_{cc}^2 = 20$ , and so on), and the payoffs in the linked game were calculated according to Table 2. Each experimental session included 6-10 subjects and lasted about an hour. Subjects’ earning in the experiment ranged between 10 and 70 Shekels (\$3 - \$20), mean payoff was 44.8 Shekels (\$13).

### 3.1 Results

Figure 1 presents the level of cooperation, i.e., the rate (%) that subjects decided to cooperate over time in each treatment of the study. The results reveal that subjects were more cooperative when the games were linked. The overall rate of cooperation in the linked treatment was 37%, while the cooperation rate was only 25% in the isolated treatment.<sup>3</sup> A Mann-Whitney nonparametric test shows that this difference is significant,  $Z = 2.25, p = 0.012$ .

An analysis of the rate of agents cooperation in the first round (initial cooperation) shows cooperation rate of 52% in the linked games treatment, which was significantly higher than the

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<sup>3</sup> In both treatments, we consider the player’s cooperation rate in each round as 1 if s/he cooperated in both games, 0.5 if s/he cooperated in one of the two games, and 0 if s/he did not cooperate at all.

36% cooperation rate in the isolated games treatment,  $Z=1.65$ ,  $p=0.049$ . These results support our hypothesis that issue linkage in multi issue conflict may facilitate cooperation.

The difference between treatments over time were evaluated by a repeated measures ANOVA, and the results confirm higher cooperation rate in the linked games than in the isolated games,  $F(1, 76) = 3.96$ ,  $p = 0.050$ . The repeated measures analysis further shows that in both treatments the rate of cooperation decreases with rounds,  $F(1, 4) = 2.33$ ,  $p = 0.056$ . Interestingly, the results suggest an endgame effect mainly in the linked treatment: cooperation rate dropped from 36% in round 29 to 21% in the last round, but the endgame effect was much more subtle in the isolated treatment, dropping from 25% in round 29 to 23% in the last round.

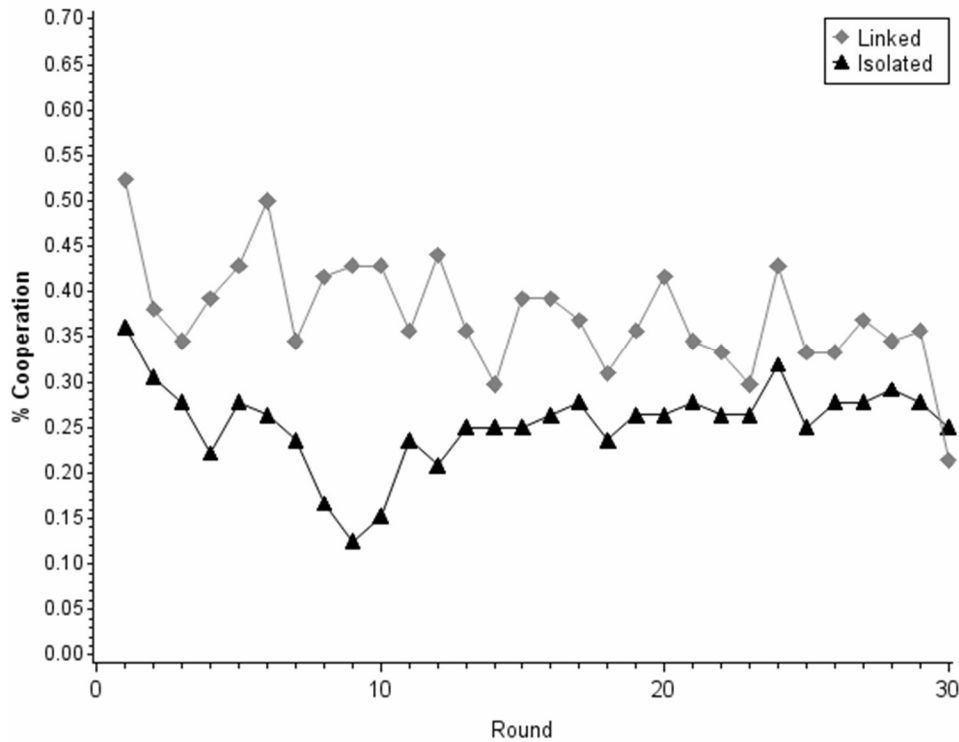


Figure 1: Cooperation rate per round in the linked and isolated treatments in Experiment 1

Table 3 presents the type of actions made by agents in the isolated and linked games. We differentiated between three action categories, listed at the top of the table for what agents were doing in each game: (1) both cooperated, (2) both defected, and (3) one was cooperating while the other was not.

Table 3: Type of cooperation within pairs in the isolated and linked treatments in Experiment 1 (no. of obs. in parenthesis)

	Both cooperating		Unilateral defection		Both Defecting	
	Isolated (18)	Linked (21)	Isolated (18)	Linked (21)	Isolated (18)	Linked (21)
First 5 rounds	11.7%	11.4%	34.4%	63.8%	53.9%	24.8%
Last 5 rounds	15.6%	17.1%	23.9%	38.1%	60.6%	44.8%
All rounds	12.9%	17.3%	25.2%	47.1%	61.9%	35.6%

The table shows that the higher cooperation rate in the linked treatment seems to emerge from both higher rate of pairs who reached mutual cooperation, and lower rate of pairs who were mutually defecting. In addition, the proportion of cases in which at least one side was cooperating (i.e., unilateral defection) was also higher in the linked treatment than in the isolated one.

#### 4 Experiment 2: The Effect of Payoff Inequality from Issue Linkage on Cooperation

The first experiment suggests a first evidence for the value of issue linkage in facilitating cooperation between players. The goal of Experiment 2 is to examine whether this observation holds when the players' payoffs are asymmetric. That is, when one player receives higher benefits than the other player, even when the games are viewed holistically.

The theoretical analysis of rational agents when at least one of the games is characterized as PD predicts that linking two games is advantageous when the two games have highly asymmetric payoff structures and are convex (Pham Do and Dinar 2014). This theoretical prediction does not depend on whether payoffs are symmetric across games. However empirical evidence suggests that context that includes asymmetrical benefits might raise equity concerns that affect strategic behavior (Fehr and Schmidt 1999; Ert, Erev, and Roth 2011). Equity concerns were found to affect policy makers (Dannenberg, Sturm, and Vogt 2010), and to be relevant to water negotiations (Marchiori 2010). Therefore, the presence of high payoff inequality across games might pose a challenge to issue linkage.

The apparatus and procedure of Experiment 2 was identical to that of Experiment 1, with the exception of the players' payoffs in each game (Appendix A). Seventy students participated in Experiment 2: 36 subjects were assigned to the "isolated" treatment and 34 subjects were assigned to the "linked" treatment. As in the previous experiment subjects played the PD games in 30 consecutive trials. The exact payoffs from each action in one game were identical to these of Experiment 1, where:  $B_{cc}^1 = 20, B_{cc}^2 = 11, B_{dc}^1 = 25, B_{dc}^2 = 0, B_{cd}^1 = 0, B_{cd}^2 = 15$ , and  $B_{dd}^1 = 10, B_{dd}^2 = 10$ . Yet the payoff scheme in the second game was not a mirror image of the payoff scheme in the first game. Specifically player 1's payoffs in the second game were identical to player 2's payoff in the first game, but player 2's payoffs in the second game were twice as much than those of player 1 on the first game (e.g.,  $V_{cc}^1 = 11, V_{cc}^2 = 40, V_{dc}^1 = 0, V_{dc}^2 = 50$ , and so on). Therefore, one player received higher potential benefits from the two games. The payoffs in the linked game were calculated according to Table 2. Each experimental session included 6-12 subjects and lasted about an hour. Subjects' earning in the experiment ranged between 10 and 108 shekels (\$5 - \$20), mean payoff was 50.8 Shekels (\$13).

#### 4.1 Results

We start our analysis by comparing the cooperation rate between the isolated and linked treatments (Figure 2). The results reveal that, despite the asymmetry between the players' payoffs, subjects were more cooperative when the games were linked. The overall rate of cooperation in the linked treatment was 29%, while the cooperation rate was only 15% in the isolated treatment. A Mann-Whitney nonparametric test shows that this difference is significant,  $Z = 12.29, p < 0.0001$ .

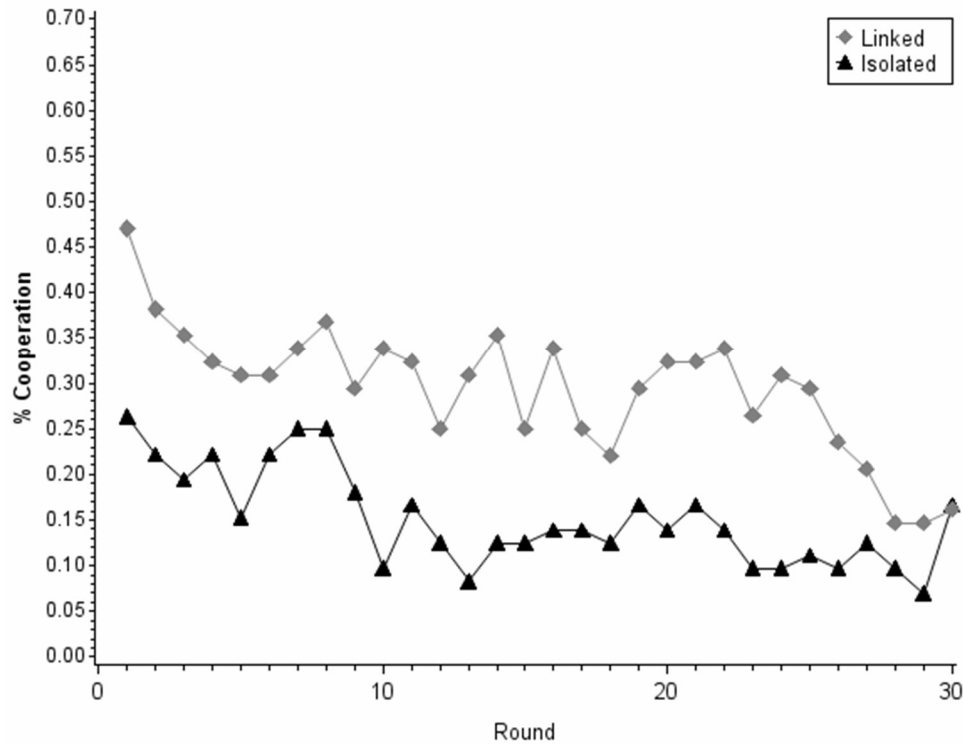


Figure 2: Cooperation rate per round in the linked and isolated treatments in Experiment 2

The difference between treatments over time were evaluated by a repeated measures ANOVA, and the results confirm higher cooperation rate in the linked treatment than in the isolated treatment,  $F(1, 58) = 7.28$ ,  $p = 0.009$ . A repeated measures analysis further shows that in both treatments the rate of cooperation decreases with rounds,  $F(1, 4) = 8.23$ ,  $p < 0.001$ .

Table 4 shows the type of actions made by agents in the isolated and linked games, differentiating between mutual cooperation, mutual defection, and unilateral cooperation. The results reveal that, similarly to Experiment 1, issue linkage somewhat increased the level of mutual cooperation, while it mostly decreased the level of mutual defection, and increased the proportion of cases in which at least one agent cooperated.

Table 4: Type of cooperation within pairs in the isolated and linked treatments (no. of obs. in parenthesis)

	Both cooperating		Unilateral defection		Both Defecting	
	Isol. (18)	Link. (17)	Isol. (18)	Link. (17)	Isol. (18)	Link. (17)
First block	5.0%	8.2%	32.2%	70.6%	62.8%	21.2%
Last block	4.4%	4.7%	13.3%	38.8%	82.2%	56.5%
All blocks	5.8%	7.5%	18.7%	57.8%	75.5%	34.7%

A natural question is whether defection in the current experiment was driven by the lowered paid player. The results do not suggest strong evidence for this hypothesis. Overall, cooperation rates do not seem to differ by players (14.8% and 15.6% for players 1 and 2 respectively in the isolated treatment and 29% for both in the linked treatment). There is some difference at the very first trial in which 33% of the higher paid player cooperated while only 19% of the lowered player cooperated in the isolated treatment, and 44% of the higher paid players and 50% of the lowered paid players cooperated in the linked treatment.

## 5 The Effects of Payoff Asymmetry and Issue Linkage: A Cross-study Analysis

In order to estimate the impact of asymmetry on the level of cooperation under linkage we conducted a cross-study analysis by running a regression that evaluated the effect of issue-linkage and payoff-asymmetry on the rate of cooperation. The results reveal that asymmetry decrease the rate of cooperation by about 9% ( $t(1) = -2.06$ ,  $p = 0.041$ ), while issue linkage increase the rate of cooperation by about 13%, ( $t(1) = 2.95$ ,  $p = 0.004$ ). We also ran another analysis that adds the effect of interaction between issue-linkage and payoff asymmetry on cooperation and found similar results for the effects of issue linkage and asymmetry, and no interaction effect ( $t < 1$ ). These results suggest that asymmetry in payoffs decreases cooperation. However, even when the payoffs are asymmetric issue linkage yields more cooperation than playing the games in isolation.

## 6 Discussion and Conclusions

Most of the world's transboundary basins are bilateral. Bilateral conflicts between riparians tend to have the nature of the classic prisoner dilemma game (e.g., Pham Do, Dinar, and McKinney 2012). Another core feature of these problems is that they involve more than one conflicting issue to solve. Despite the value of experimental research in examining causal effects, there are almost no experiments of transboundary basin problems (one exception is Abbink et al. (2010)). Furthermore, the experimental studies of prisoner dilemmas have been exclusively focused on situations that require only a single issue to resolve, and almost exclusively focused on symmetrical payoff structure in which both agents face the same potential payoffs. Therefore, the current experimental literature falls short of capturing important aspects of bilateral transboundary problems. For example, while several theoretical papers highlight the importance of issue linkage in facilitating cooperation (Pham Do, Dinar, and McKinney 2012; Just and Netanyahu 2000), we have not found even a single paper that experimentally tests this proposition.

In this paper we proposed a new experimental design that resembles multi-issue bilateral conflicts where each issue that requires solution is modeled as a different game to be played. This analysis extends the study of a single-issue PD games to studying two-issues PD games that are more complex in nature but may also offer more opportunities for cooperation, especially when payoffs are asymmetric. We presented two experimental studies, designed to evaluate the effect of issue linkage on cooperation by comparing an isolated-games treatment in which agents played the two PD games successively, with a linked-games treatment where the two games were linked into one. The results revealed that the cooperation rate across rounds is low in the isolated games (only 27% in Experiment 1, and 15% in Experiment 2), a finding that is consistent with previous analyses of asymmetric PD games (Croson 1999). This finding, and the lower cooperation rate in Experiment 2 in which the payoff asymmetry could not be resolved by issue linkage, suggests that the agents are indeed affected by equity concerns. However, it is worth noticing that in Experiment 1 low cooperation rate was observed despite the fact that payoff equality could be maintained (since the payoff structure in one game was a mirror image of the second). That is, cooperation in the second game could “correct” for the payoff asymmetry resulted from cooperation in the first game. Therefore, the low rate of cooperation cannot be solely attributed to equity concerns. It seems that when the games are played in isolation it



might be harder for the agents to differentiate the forest from its trees thereby they might overlook opportunities for mutual benefits.

The main finding of our experiments shows that issue linkage has a positive effect on cooperation. The cooperation rate in the linked treatment was significantly higher than in the isolated treatment in both experiments. Furthermore, additional analysis suggests that issue linkage tend to increase mutual cooperation and decrease mutual defection, compared to playing the games in isolation. However, the results also suggest that linking the issues does not seem to resolve the declining cooperation over time, a typical finding of (single) PD experiments as well as in ours. It seems that the cooperation rate declines considerably in the linked games as well, especially towards the end of the experiment. This finding, while preliminary, calls for further investigation and might suggest the importance of the shadow of the future in bilateral multi-issue conflicts. In general, our experimental findings support to the theoretical prediction that issue linkage promotes cooperation.

The current investigation could, and in our view, should be broadened to examine additional important questions that are relevant to multi-issue conflicts. One venue for future research is further studying the nature of multi-issue bilateral conflicts. While we used two PD games the analysis could be used to study other games that might relate to other issues of interest. For example, not all issues on the negotiation table necessarily include zero sum games, and the current design could be expended for studying non zero-sum games. Future studies could also address potential features of importance that were shown to influence single PD games, e.g., the certainty in payoffs. While the vast majority of PD analyses use certain payoffs for simplicity (and in this paper we followed this convention), payoffs related to real problems and environmental problems in particular tend to involve uncertain payoffs, which makes cooperation and coordination even more challenging.

Another natural venue for future use of our design is extending the analysis from two-player games to n-player games. Considerable amount of transboundary basins, for example, include more than two agents, and n-player dilemmas offer new complexities and opportunities than two-player games. We should note that while our main motivation for the current paper stems from the nature of transboundary problems, the characteristic of multiple issues of conflict should be relevant to many other environmental conflicts and international environmental

agreements. We hope that the current analysis will help in facilitating more experimental work that acknowledges the importance of studying multi-issue negotiations, and test the nature of these kind of problems that seem very relevant to many conflicts in the real world.

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## Appendix A. Experiment 1: Translated Instructions

### a. Isolated Games Treatment

Hello,

In this experiment you will be asked to play two different games, each one for 30 rounds. In each game you may earn or lose money depending on the decisions taken by you and by the other player in the game. The games are independent. Two games to play in each round (one after the other), based on 2 players per game: you and your competitor throughout the entire experiment. In every game you may choose either to “cooperate” or “not cooperate”.

Your rewards are highlighted in green as shown in the table below:

		You	
		Cooperate	Not cooperate
Second player	Cooperate	20 11	25 0
	Not cooperate	0 15	10 10

Game 1 possible results are as follow:

- If you choose to "cooperate" and the second player chooses to "cooperate", you get 20 points, and the other player gets 11 points.
- If you choose to "cooperate" and the other player chooses "not cooperate", you get 0 points, and the other player gets 15 points.
- If you choose "not cooperate" and the other player chooses to "cooperate", you get 25 points, and the other player gets 0 points.
- If you choose "not cooperate" with the other player selects "not cooperate", you get 10 points, and the other player gets 10 points.

The possible outcome in game 2 are exactly the opposite to game 1 (for example, if you and the other player choose to "cooperate", you get 11 points and the other player gets 20 points).

At the end of each round the screen will show your choice, the second player's choice, and the resulting payoffs for that round.

At the end of the experiment one round will be randomly sampled (all rounds have the same probability of being sampled). The final payment for the experiment is based on 10 Shekels showing up fee, added to the payoff from the randomly sampled round (according to conversion rate of 1 pt = 1.5 Shekels).

Good luck!

## b. Linked Games Treatment

Hello,

In this experiment you will be asked to play two linked games, each one for 30 rounds. In each game you may earn or lose money depending on the decisions taken by you and by the other player in the game. The games are independent.

Each game includes 2 players: you and another player who will be randomly selected from the participants in the room as the experiment begins (each player has equal chance of playing with you). You will play all games with the same player.

In each of the games you face two choice options: “cooperate” or “not cooperate”. At the beginning of each round you will make your decision for the two games simultaneously. Specifically, you will have to choose whether to cooperate in both games (“cooperate”, “cooperate”), cooperate in the first but not in the second game (cooperate, not cooperate), not cooperate in the first game but cooperate in the second (not cooperate, cooperate), or not cooperate in both games (not cooperate, not cooperate). Your rewards are highlighted in green as shown in the table below:

You \ Second player	Cooperate, Cooperate	Cooperate, Not cooperate	Not cooperate, Cooperate	Not cooperate, Not cooperate
Cooperate, Cooperate	31 / 31	35 / 11	36 / 20	40 / 0
Cooperate, Not cooperate	20 / 36	30 / 21	25 / 25	35 / 10
Not cooperate, Cooperate	11 / 35	15 / 15	21 / 30	25 / 10
Not cooperate, Not cooperate	0 / 40	10 / 25	10 / 35	20 / 20

Let us review some actions and resulting outcomes in the Table for clarification:

1. Suppose the second player choose to cooperate in both games (“cooperate”, “cooperate” as presented by the first row in the table), in such case:
  - if you cooperate in both games (“cooperate”, “cooperate”) then each player receive 31.
  - alternatively if you decide to cooperate in the first game and not to cooperate in the second game (“cooperate”, “not cooperate”) you get 35 and the other player gets 11.
  - if you choose not cooperate in the first game and cooperate in the second (“not cooperate” cooperate”) you get 36 and the other player gets 20.

-and if you decide not to cooperate in both games (“not cooperate”, “not cooperate”) you get 40 and the other player gets 0.

2. Now suppose the second player decides not to cooperate in both games (“not cooperate”, “not cooperate” as presented by the bottom row in the table), in such case:

- if you cooperate in both games (“cooperate”, “cooperate”) then you get 0 and the other player gets 40.

-alternatively if you decide to cooperate in the first game and not to cooperate in the second game (“cooperate”, “not cooperate”) you get 10 and the other player gets 25.

-if you choose not to cooperate in the first game and cooperate in the second (“not cooperate” cooperate”) you get 10 and the other player gets 35.

-and if you decide not to cooperate in both games (“not cooperate”, “not cooperate”) then each player gets you get 40 and the other player gets 20.

In a similar manner one can analyze the possible choices of the two players and their resulting payoffs in case where the other player cooperates in the first and not in the second game (“cooperate”, “not cooperate”), and in the case where the other player does not cooperate in the first game and cooperate in the second game (“not cooperate” cooperate”)

At the end of each round the screen will show your choice, the second player’s choice, and the resulting payoffs for that round.

At the end of the experiment one round will be randomly sampled (all rounds have the same probability of being sampled). The final payment for the experiment is based on 10 Shekels showing up fee, added to the payoff from the randomly sampled round (according to conversion rate of 1 pt = 1.5 Shekels).

Good luck!