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The effect of issue linkage on cooperation in bilateral conflicts: An experimental analysis[☆]

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ABSTRACT

Bilateral conflicts, e.g., common pool resource allocation, pollution prevention, collusion of markets, or share transboundary water, often involve more than one issue that requires solution. The theoretical literature suggests that linking conflictive issues opens new opportunities for cooperation. We present a new experimental setting of bilateral conflicts, in which each issue is modeled as a separate Prisoner's 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 acts 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). We find that issue linkage increases mutual cooperation and decreases mutual defection. Asymmetry reduces the level of cooperation in both isolated and linked games, yet issue linkage facilitates cooperation even when payoffs are asymmetric.

1. Introduction

Issue linkage refers to the simultaneous discussion of two or more issues for joint settlement. This concept has been used to provide a solution to conflicts where more than one conflictive issue is at stake. Examples of use of issue linkage in actual negotiations include peace agreements between nations (Haddadin, 2002) and rebel groups (Government of Columbia, 2016), trade agreement (Aggarwal, 2013), alliance negotiations among states in Europe (Poast, 2012), and transboundary water agreements (Ambec et al., 2013), to name a few. While our paper refers to the general concept of issue linkage and its application for solving gridlock in negotiation in the lab, we would refer to and use examples from the field of transboundary water conflicts in order to demonstrate its usefulness.

Transboundary river 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 et al., 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, as well the other examples we presented earlier, 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 different issues could transform the

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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 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 et al., 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 more 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 two-parties 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.

2. Can issue linkage help mitigate externalities in bilateral conflicts?

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 conflicts can often be presented as a Prisoner's Dilemma (PD) game. For example, in the case of trans-boundary basins the upstream country chooses between sharing (cooperate) or not sharing (defect) water with the downstream (subject to rules established in international law). 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 in 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 such multi-issue conflict: 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 through analyzing the payoffs when the issues are negotiated in isolation and when they are negotiated under linkage. Each issue is modeled as a Prisoner's 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:

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

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.

Issue linkage refers to the situations where the two issues of conflict, modeled here as two separate 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 a situation to test the degree to which players respond to opportunities from payoff linkage.

3. Previous relevant work

We review three veins of the literature that applies experimental economics to address relevant Prisoner's Dilemma questions, experiments on relevant water-related questions, and experiments on multiple negotiated issues, all are part of the framework addressed in our work. In each of these subsections we do highlight also the differences between the existing literature and our work.

3.1. Experimental studies on repeated Prisoner's Dilemma

The Prisoner's Dilemma game has been the target of extensive experimental research in economics (Kagel and Roth, 1995), with over 1000 experiments, most of which used iterated choices in a repeated game setting (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

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 1	C	B_{cc}^1, B_{cc}^2	B_{cd}^1, B_{cd}^2	Player 1	C	V_{cc}^1, V_{cc}^2	V_{cd}^1, V_{cd}^2
	D	B_{dc}^1, B_{dc}^2	B_{dd}^1, B_{dd}^2		D	V_{dc}^1, V_{dc}^2	V_{dd}^1, V_{dd}^2

Table 2
Normal form presentation of the linked games/issues.^a

		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	$B_{dc}^1 + V_{cc}^1, B_{dc}^2 + V_{cc}^2$	$B_{dc}^1 + V_{cd}^1, B_{dc}^2 + V_{cd}^2$	$B_{dc}^1 + V_{dc}^1, B_{dc}^2 + V_{dc}^2$	$B_{dc}^1 + V_{dd}^1, B_{dc}^2 + V_{dd}^2$
	DD	$B_{dc}^1 + V_{dc}^1, B_{dc}^2 + V_{dc}^2$	$B_{dc}^1 + V_{dd}^1, B_{dc}^2 + V_{dd}^2$	$B_{dd}^1 + V_{dc}^1, B_{dd}^2 + V_{dc}^2$	$B_{dd}^1 + V_{dd}^1, B_{dd}^2 + V_{dd}^2$

^a Notice that [Tables 1](#) and [2](#) suggest a general form that could be used for any 2×2 games, not only prisoner dilemma games. The nature of the game is defined by the relative payoffs that are implemented in the games.

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 et al., 2007](#); [Sheposh and Gallo, 1973](#); [Andreoni and Varian, 1999](#)).¹ 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.

Our 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. 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, one of the agents might benefit more from issue/game linkage than the other. 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 is studied in Experiment 2.

3.2. Experimental studies on multiple games/issues

Experimental work on conflicts over more than one issue is also scarce. One research vein has examined multi-stage Prisoner's Dilemma that is composed of several PD interconnected subgames. In each subgame the player's action determines not only the payoff but also the probability of the next subgame/conflict to be played ([Rapoport, 1967](#)). Experimental studies of these games have shown that players are aware of the delicate strategic considerations involved in the game ([Rapoport, 1990](#)). Notice, that the interdependency between games implies that

players need to think and react to multiple games, nevertheless this structure is less relevant to the current analysis that assesses whether multiple conflicts would be played differently when they are played simultaneously or in isolation.

Another class of studies has examined cooperation in the contexts of oligopolies and multimarket contacts, where firms compete or collude in more than one market. [Feinberg and Sherman \(1988\)](#) examined symmetric three-market price-setting experiments to find that having the same competitor across markets facilitate cooperation. This phenomenon is attributed to the expectation that one firm may have about its rival response in another market ([Feinberg, 1984](#)). [Phillips and Mason \(1992\)](#) examined two-market-quantity-setting experiments, but have not found higher cooperation in multi-markets than in single ones. Few experiments even used Prisoner's Dilemma games. Perhaps the closest examination to our analysis is a recent experiment of multi-market contact that compared behavior in a symmetric single and a combined Prisoner's Dilemma ([Yang et al., 2016](#)). Interestingly, the results showed a reduced cooperation in the combined game, suggesting that multi-market contact might not always facilitate, but can also inhibit, cooperation.

There are several notable differences between those experiments and ours. Perhaps the most notable difference is that the in the multi-games experiments each game is symmetric, while a core feature of our current framework is the payoffs asymmetry between players. This feature is important because the payoff asymmetry is the exact factor that opens opportunities for mutual benefit gain from issue linkage, which would not be possible when the games are symmetric.

3.3. Experimental studies on choice bracketing

Decisions involving more than a single issue may also raise the question of “choice bracketing.” People facing two or more decisions may “narrowly bracket” them by making each choice in isolation, or “broadly bracket” them by assessing the consequence of taking them together ([Read et al., 1999](#); [Tversky and Kahneman, 1981](#)). The main finding of those studies is that people tend to narrowly bracket multiple decisions, which might even result in choosing dominated combinations ([Rabin and Weizsäcker, 2009](#)). Most choice bracketing studies have focused on individual choice. More recent studies have begun to explore its relevance to behavioral games. For example, [Stracke et al. \(2017\)](#) suggest that in two-stage elimination contests people might neglect the option value of participating in the later stage unless future looking behavior is induced by framing ([Stracke et al., 2017](#)).

One implication of this line of research to the current study is that players would overlook potential roots for cooperation, unless the games/issues would be explicitly linked.

4. 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's Dilemma games separately, each focusing on a different issue under

¹ [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.

Fig. 1. Cooperation rate per round in the linked and isolated treatments in Experiment 1.

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 each subject signed an informed consent and received written instructions (Appendix B), 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 rounds, after each of which the players received feedback regarding the game outcome in that round 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 rounds. 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).

4.1. Results

Fig. 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 ($Z = 1.44$, $p = 0.075$; one tailed, Mann Whitney test, clustered at the pair level).²

² In both treatments, we consider each 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.

An analysis of the rate of agents cooperation in the first round (initial cooperation) shows cooperation rate of 52% in the linked games treatment, and only 36% cooperation rate in the isolated games treatment ($Z = 1.57$, $p = 0.057$; one tailed, MW test clustered at the pair level). These results support our hypothesis that issue linkage in multi issue conflict may facilitate cooperation.

Table 3 presents a regression analysis testing the effects of treatment, round, and their interaction on cooperation rate within the pairs while playing the games. The results reveal that the cooperation rate is positively affected by issue linkage. The result also reveal a negative yet insignificant effect of rounds, but a significant effect of its interaction with the treatment.

Table 4 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.

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. The differences occur from the very beginning, i.e., first five rounds, and seem to decrease by the end of the interaction.

5. Experiment 2: The effect of payoff inequality from issue linkage on cooperation

The first experiment suggests an initial 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 games have highly asymmetric payoff structures and are substitutes (i.e., when benefits from cooperation in one game may compensate for losses from cooperation in the other (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 et al., 2011). Equity concerns were found to affect policy makers (Dannenberg et al., 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: thirty-six subjects were assigned to the “isolated” treatment and 34 subjects were assigned to the “linked” treatment. Subjects in each treatment were randomly assigned to their role as player 1 or player 2. As in the previous experiment subjects played the PD games in 30 consecutive rounds. For the second game (game 2), the exact payoffs from each action were identical to these of Experiment 1: $V_{cc}^1 = 11$, $V_{cc}^2 = 20$, $V_{dc}^1 = 15$, $V_{dc}^2 = 0$, $V_{cd}^1 = 25$, and $V_{dd}^1 = 10$, $V_{dd}^2 = 10$. Yet, the first game (game 1) was not a mirror image of game 2. Specifically, Player 2’s payoffs in game 1 were identical to player 1’s payoff in game 2, but player 1’s payoffs in game 1 were twice as much as those of player 2 on game 2 (e.g., $B_{cc}^1 = 40$, $B_{cc}^2 = 11$, $B_{dc}^1 = 50$, $B_{dc}^2 = 0$, and so on; see Appendix A.2). Therefore, one player

(footnote continued)

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.

Table 3
Regression of cooperation rate per round in Experiment 1.

	(1)	(2)	(3)
Treatment (linked = 1)	0.120*** (0.020)	0.120*** (0.02)	0.196*** (0.042)
Round		−0.0017 (0.001)	−0.001 (0.002)
Round × treatment			−0.005* (0.002)
Constant	0.254*** (0.015)	0.281*** (0.024)	0.240*** (0.031)
Observations	1170	1170	1170
Cluster level	Pairs	Pairs	Pairs
No. of clusters	39	39	39
Adj. R ²	0.03	0.03	0.03

Standard errors in parenthesis.

* $p < 0.05$, *** $p < 0.001$.

Table 4
Type of cooperation within pairs in the isolated and linked treatments across rounds.

	Both cooperating (%)		Unilateral defection (%)		Both defecting (%)	
	Isolated (18) ^a	Linked (21)	Isolated (18)	Linked (21)	Isolated (18)	Linked (21)
First 5 rounds	11.7	22.4	34.4	38.1	53.9	39.5
Last 5 rounds	15.6	20.0	23.9	24.8	60.6	55.2
All rounds	12.9	23.6	25.2	27.7	61.9	48.6

^a Number of pairs in parenthesis.

Fig. 2. Cooperation rate per round in the linked and isolated treatments in Experiment 2.

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).

5.1. Results

We start our analysis by comparing the cooperation rate between the isolated and linked treatments (Fig. 2). The results reveal that, despite the asymmetry between the players' payoffs, subjects were more

Table 5
Regression of cooperation rate per round in Experiment 2.

	(1)	(2)	(3)
Treatment (linked = 1)	0.142*** (0.017)	0.142*** (0.017)	0.169*** (0.035)
Round		−0.005*** (0.001)	−0.004*** (0.001)
Round × treatment			−0.002 (0.002)
Constant	0.152*** (0.012)	0.231*** (0.019)	0.218*** (0.024)
Observations	1050	1050	1050
Cluster level	Pairs	Pairs	Pairs
No. of clusters	35	35	35
Adj. R ²	0.06	0.08	0.09

Standard errors in parenthesis.

*** $p < 0.001$.

Table 6
Type of cooperation within pairs in the isolated and linked treatments across rounds.

	Both cooperating (%)		Unilateral defection (%)		Both defecting (%)	
	Isolated (18) ^a	Linked (17)	Isolated (18)	Linked (17)	Isolated (18)	Linked (17)
First 5 rounds	5.0	15.3	32.2	42.9	62.8	41.8
Last 5 rounds	4.4	6.5	13.3	22.9	82.2	70.6
All rounds	5.8	12.6	18.7	33.5	75.5	53.8

^a Number of pairs in parenthesis.

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 (one tailed, at the pair level) shows that this difference is significant, $Z = 2.78$, $p = 0.003$.

Table 5 presents an analysis testing the effects of treatment, round, and their interaction on cooperation rate within the pairs while playing the games. The results reveal that cooperation rate is positively affected by issue linkage, and that it is negatively affected by time (rounds). The interaction between the treatment and round was found to be insignificant.

Table 6 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.

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 round 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.

6. 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

Table 7

A cross-study regression analysis for the effects of linkage and asymmetry on cooperation.

	(1)	(2)	(3)
Linkage	0.131*** (0.013)	0.131*** (0.013)	0.120*** (0.019)
Asymmetry	−0.091*** (0.013)	−0.091*** (0.013)	−0.103*** (0.019)
Round		−0.003*** (0.001)	−0.003*** (0.001)
Linkage × asymmetry			0.022 (0.027)
Constant	0.249*** (0.012)	0.301*** (0.017)	0.306*** (0.018)
Observations	1905	1905	1905
Cluster level	Pairs	Pairs	Pairs
No. of clusters	74	74	74
Adj. R ²	0.06	0.07	0.07

Standard errors in parenthesis.

*** $p < 0.001$.

running a regression that evaluated the effect of issue linkage and payoff-asymmetry on the rate of cooperation. The results, presented in Table 7, reveal that asymmetry decreases the rate of cooperation by about 9–10%, while issue linkage significantly increases the rate of cooperation by about 12–13%. We also ran another analysis that adds the effect of interaction between issue linkage and payoff asymmetry on cooperation (Model 3 in Table 7) and found similar results for the effects of issue linkage and for asymmetry, but no interaction effect. These results suggest that asymmetry in payoffs decreases the level of cooperation. However, even when the payoffs are asymmetric issue linkage yields more cooperation than playing the games in isolation.

7. Discussion and conclusions

Bilateral conflicts often involve more than one conflicting issue to solve, and many could be described as a Prisoner's Dilemma game (e.g., Pham Do et al., 2012). Yet the experimental studies of Prisoner's Dilemmas have been exclusively focused on situations that require only a single issue to resolve, and almost exclusively focused on a symmetrical payoff structure in which both agents face the same potential payoffs. Therefore, the current experimental literature falls short of capturing important aspects of many bilateral conflicts. For example, while several theoretical papers highlight the importance of issue linkage in facilitating cooperation (Pham Do et al., 2012; Just and Netanyahu, 2000), we have not found experiments that directly test 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. In light of this observation one might question whether added value of issue linkage might decline over time as well. The current research shows somewhat inconclusive evidence in this respect, as the interaction between issue linkage and round was significant in Experiment 1 but insignificant in Experiment 2. Furthermore, the current design is insufficient to identify the reasons for such potential decline that could be driven by endgame effects, or by subjects learning over time, or both, or other reasons. These findings, while preliminary, call for further investigation and might suggest the importance of the shadow of the future in bilateral multi-issue conflicts.

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 have the structure of cooperation-competition dilemmas like the PD game. Other contexts of interest may include issues of coordination and trust, such as those modeled by the stag hunt and assurance games. The current design could be easily extended to study those other contexts and 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.

Appendix A: The payoffs matrices used in the experiments

1. Experiment 1

Isolated:

Game/issue 1		Player 2		Game/issue 2		Player 2	
		C	D			C	D
Player 1	C	20, 11	0, 15	Player 1	C	11, 20	0, 25
	D	25, 0	10, 10		D	15, 0	10, 10

Linked:

		Player 2				Player 2	
		CC	CD			DC	DD
Player 1	CC	31, 31	20, 36			11, 35	0, 40
	CD	35, 11	30, 21			15, 15	10, 25
	DC	36, 20	25, 25			21, 30	10, 35
	DD	40, 0	35, 10			25, 10	20, 20

2. Experiment 2

Isolated:

Game/issue 1		Player 2		Game/issue 2		Player 2	
		C	D			C	D
Player 1	C	40, 11	0, 15	Player 1	C	11, 20	0, 25
	D	50, 0	20, 10		D	15, 0	10, 10

Linked:

		Player 2				Player 2	
		CC	CD			DC	DD
Player 1	CC	51, 31	40, 36			11, 35	0, 40
	CD	55, 11	50, 21			15, 15	10, 25
	DC	61, 20	50, 25			31, 30	20, 35
	DD	65, 0	60, 10			35, 10	30, 20

Appendix B. Experiment 1: Translated instructions

B.1. 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 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.2. 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 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	11 / 35	20 / 36	0 / 40
Cooperate, Not cooperate	36 / 20	21 / 30	25 / 25	10 / 35
Not cooperate, Cooperate	35 / 11	15 / 15	30 / 21	10 / 25
Not cooperate, Not cooperate	40 / 0	25 / 10	35 / 10	20 / 20

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

- 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.
- 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!

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