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Breaking the Violence: Attaining Peaceful Relations in Games of Conflict

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Abstract

We extend the Hirshleifer-Skaperdas conflict game with a post-contest phase which varies in the type of actions players can engage in once the winner of the contest is determined. Moreover, players have the option to avoid conflict altogether and build a peaceful relationship. We show experimentally that the possibility of conditional retaliation by the defeated player is crucial for efficiency improving adaptive behavior of contestants. Our main finding is that conflict levels are considerably reduced mostly because some groups manage to attain peace, often after substantial initial conflict. For the engineering of peace it turns out to be important that players first engage in costly signaling by making themselves vulnerable and by forgoing the possibility to take resources (money) away from their opponent. The behavioral environments of the extended conflict games examined in this paper vary in the opportunities offered in this respect.

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1 Introduction

This paper presents an experimental study of conflict focusing on the role of the aftermath of contests and on related behavioral factors promoting peace. Our paper aims to contribute to the gradually growing stream of studies on the economics of conflict that started about two decades ago. The focus of attention in these studies is the choice between production and appropriation as means to pursue wealth. Although often put in military "guns and butter" terms, the relevance of conflict models is much wider as they not only capture important aspects of war related activity but also of phenomena like litigation, redistributive politics (e.g. election campaigns), intra-firm politics (like promotion tournaments), and business contests (R&D, marketing, takeovers), and more generally cases where property rights are disputable or not well-defined. In all these cases, players (nations, firms, social groups) face an important choice between investing more efforts into production or into "predation". In the paradigmatic models of Hirshleifer (1988, 1991a) and Skaperdas (1992) this choice is embedded in a contest between two players whose investment of resources in appropriative efforts determines the probability of winning the contest and obtaining the loser's production. More specifically, this probability is determined by a "contest success function" as in the pioneering rent-seeking model of Tullock (1980). The main differences between conflict models and rent-seeking models are that in the former the contested prize is endogenous and resources are locked into the contest (no safe haven; Neary, 1997a). In the meantime this literature has branched into various directions - for example, dealing with defensive activities and intertemporal issues - and seems to be merging into a more general theory of contests. See the excellent surveys of Garfinkel and Skaperdas (2007) and Konrad (2009).[1]

In contrast to the theoretical literature, experimental studies of conflict models are relatively scarce and of more recent date (for a survey, see Abbink, 2010).[2] Starting point is the Durham et al. (1998) test of the model of Hirshleifer (1991a). Durham et al. (1998) examine how changes in the technology of conflict (the contest success function) affect productive activities and the manifestation of the "paradox of power" (the poorer contestant improving her economic position relative to the richer). Carter and Anderton (2001) conduct a similar experiment but with an asymmetric assignment of roles based on the predator-prey model of Grossman and Kim (1995, 1996). This model builds on the Hirshleifer-Skaperdas model by assuming independent

[1]See e.g. Grossman and Kim (1995, 1996), McBride and Skaperdas (2009), Neary (1997b), Skaperdas (1991), and Skaperdas and Syropoulos (1996).

[2]For surveys of rent-seeking experiments, see Öncüler and Croson (2005) and Herrmann and Orzen (2008).

production and initial claims to resources instead of a common pool of resources and joint production. Moreover, one player (the first mover) is restricted to defense. They find that increases in the relative effectiveness of predation against defense leads to behavioral changes in line with the theoretical prediction. Duffy and Kim (2005) test a model of anarchy where (ten) subjects repeatedly choose whether they want to be predators or producers (going for defense only). Some support for convergence towards the theoretical predictions, both regarding the number of predators and the level of defense, is obtained. Powell and Wilson (2008) also study anarchy in the lab but with much less structure, allowing (six) subjects to choose in real time between offense, defense and production. Although no universal cooperation (without any defense and offense) is observed, the level of cooperation is much higher than expected. Finally, we mention here the study by McBride and Skaperdas (2009) where subjects can choose between a peaceful settlement and conflict. In case of conflict there is a fifty percent chance of a gain (winner) or a loss (loser). Moreover, this choice affects expected earnings from future rounds (with no further choice), determined by a continuation probability: the "shadow of the future". As predicted, it is observed that subjects choose more conflict when the chance of continuation increases.

What has been neglected in this literature so far is what happens after a contest. First of all, we notice that the appropriation of production after winning a contest is typically an act in itself and not just a technical consequence. Furthermore, the defeated may still be able to offer resistance or to apply scorched-earth tactics (Hirshleifer, 1991b), dependent on the environment or institution. To some extent this has been acknowledged by allowing for some destruction or cost of predation, but only in the form of an exogenous parameter (see e.g. Neary, 1997b; Grossman and Kim, 1995; McBride and Skaperdas, 2009). One goal of this paper is therefore to extend the Hirshleifer-Skaperdas conflict model in these two directions, assuming independent production (no common pool) as in Grossman and Kim (1995). More specifically, we investigate the following three extensions of the conflict game. In each of them we extend the game with a post-contest phase, which may consist of one or two stages.

Complete Surrender In this extension we introduce an additional post-contest stage where the winner of the contest in the first stage of the game decides how much to take of the loser's production (instead of automatically receiving all of it). The additional stage allows winners to restrain themselves, for example, out of fairness considerations or as a way to signal willingness to avoid future conflict. This case also serves as a benchmark for the other two extensions.

Resistance In this three-stage conflict game an additional stage is added in the post-contest phase where the loser - knowing how much the winner claims of his production - can decide how much of it to destroy. As an example, one could think of destroying confiscated crops or avoiding taxation through the use of a less efficient shadow economy.

Scorched Earth This game is similar to the previous one except that the second and third stage are reversed. In the post-contest phase now first the loser decides how much of his production to destroy and then the winner decides how much to appropriate of what is left. Examples include the Kuwaiti oil fires started by the Iraqi military forces in 1990 when they were driven out by the U.S. or Hitler's order to destroy all of Germany's resources when he realized he had lost the war.

As experimental treatments, all extensions will be implemented and investigated as a repeated game under both a *Strangers* and a *Partners* matching protocol; in the former subjects are randomly re-matched in each round of the game, whereas in the latter fixed pairs are used. The reason is two-fold. First, a repeated game is used to allow for learning. Second, some conflict situations are better captured by the one matching protocol than the other. For instance, warfare against different opponents may be more like Strangers while repeated electoral competition between the same parties is better captured by Partners.

A second and related goal of this paper is to investigate whether these different environments have any bearing on the occurrence of peace, that is, the universal absence of appropriative efforts (full cooperation). As Garfinkel and Skaperdas (2007) conclude in their survey: "Very little is known about how to reduce, let alone eliminate, conflict." Sometimes this is due to the fact that subjects simply have no peace option in the experiment. This holds for Durham et al. (1998) and typically for rent-seeking experiments. In case of universal zero conflict expenditure either no payoff is obtained (as in Durham et al.) or else an equal probability of winning the contest is applied. In all other experiments discussed above, where in principle peace is possible, typically little or no full cooperation is observed. On the contrary, in (rent-seeking) experiments overinvestment in conflict is a general finding. Our experimental design is admittedly stark. Nevertheless, given the importance of the issue and the fact that it might not be too unrealistic for some settings, it seems worthwhile (anticipating also our results) to start with this simple comparative analysis.

The organization of the paper is as follows. In section 2 we present and analyze the different games and describe the experimental design and procedures. Results are presented and discussed in section 3, while section 4 concludes.

2 The Experiment

In this section we present and analyze our three extensions of the Hirshleifer-Skaperdas conflict game, assuming independent production (no common pool) as in Grossman and Kim (1995). This is followed by a discussion of the experimental design and procedures. A convenient summary of all the games can be found in Table 1.

2.1 Complete Surrender (CS)

The Complete Surrender (CS) game is a two-player two-stage game. At the beginning of the first stage, each player $i \in 1, 2$ is endowed with y units of an exogenously given resource. The players decision in the first stage consists of allocating an amount c_i of their resource to "conflict", thus leaving $y - c_i$ as "production". The amount invested in conflict determines whether there is a contest between the two players and if so, each player's probability of winning it.

Unlike the majority of models in this literature, which consider conflict to be unavoidable, we allow players to avoid fighting by choosing $c_i = 0$. If both players invest zero resources in conflict then there is no contest and the game ends. In this case both players receive earnings of y. If at least one of the players invests a positive amount in conflict then there is a contest and the player's relative investments determine their probability of winning. Specifically, the probability of winning is given by[3]

$$p_i\left(c_i, c_j\right) = \frac{c_i}{c_i + c_j} \text{ if } c_i + c_j > 0. \tag{1}$$

As can be seen, if both players invest equal amounts in conflict then they have an equal probability of winning the contest. Furthermore, i's probability of winning $p_i(c_i, c_j)$ increases with her expenditures in conflict c_i and decreases with her opponent's c_j.

After the winner of the contest is determined according to (1), the second stage begins. In the second stage, the winner decides how much of the loser's production to appropriate. Specifically,

[3]We are using a special case of the commonly-used contest function where all instances of c_i and c_j are raised to the power of $m > 0$. This so-called decisiveness parameter can be interpreted as the degree of uncertainty in the determination of the winner. See Hirshleifer (1989) and **?** for an exhaustive analysis of the importance of m in conflict decisions. This functional form is also employed by Tullock (1980) and the vast literature on rent-seeking.

winner i chooses a "take rate" $t_i \in [0,1]$ which is the fraction of $1 - c_j$ that she wishes to claim. The loser makes no decision.

Therefore, if there is a contest, the expected earnings of player i are given by

$$E[\pi_i] = \frac{c_i}{c_i + c_j^e}\left(y - c_i + t_i(y - c_j^e)\right) + \frac{c_j^e}{c_i + c_j^e}\left(1 - t_j^e\right)(y - c_i), \tag{2}$$

where c_j^e and t_j^e are i's expected value for c_j and t_j. The first element of the sum corresponds to i's expected earnings if she wins multiplied by her probability of winning, and the second element is i's expected earnings if she loses multiplied by her probability of losing.

If one assumes agents are risk neutral and rationally maximize their monetary earnings then it is relatively straightforward to calculate the optimal investment in conflict. The model is solved by backward induction. In order to maximize their earnings, winners appropriate all of the losers' production. Given this, one can maximize (2) and obtain i's best reply

$$c_i(c_j) = \sqrt{2yc_j} - c_j. \tag{3}$$

Using (3) one obtains the Nash equilibrium of the game, where both players spend half of their endowment in conflict, $c^* = \frac{1}{2}y$, and each players has an equal probability of winning. Note that, it is straightforward to see that $c_i = c_j = 0$ is not a Nash equilibrium. In this case both contenders have an incentive to increase their conflict expenditures, win the contest with certainty, and take all their rival's production.

Compared to the models of Hirshleifer (1988) and Skaperdas (1992) and the experimental test by Durham et al. (1998), our game differs in that: (i) appropriable resources are not part of a common pool (Grossman and Kim, 1995), and therefore, players can avoid conflict altogether if they do not invest in conflict, (ii) investment in conflict determines only the probability of winning, and (iii) final earnings are determined by the winner. In Hirshleifer (1988), Skaperdas (1992), and Durham et al. (1998), the contest function directly determines the players' final earnings as a share of the total surplus—with our parameters this translates into i's earnings as being equal to $\pi_i = p_i(c_i, c_j)(y - c_i + y - c_j)$. Thus, our model is more representative of situations in which one party can take complete control of the other's resources (if they choose not to avoid each other). As pointed out by Neary (1997a), conflict games show some similarity to the rent-seeking model of Tullock (1980). In particular, if we do not allow players to avoid conflict when they choose $c_i = c_j = 0$ and we set $t_i = t_j = 1$ then our game becomes formally equivalent with a Tullock contest if we neglect the given endowment and assume that the prize they compete for is $2y$. Note that, under risk neutrality and own-earnings maximization, all these models result in the same expected payoff function (for a systematic comparison of conflict models see Chowdhurya and Sheremeta, 2009). However, this is no longer the case if one assumes risk aversion or other-regarding preferences. We discuss both assumptions later in this section.[4]

2.2 Scorched Earth (SE)

The Scorched Earth (SE) game has three instead of two stages. The first stage of the game is exactly the same as the first stage of CS and hence we do not repeat it here. Below we describe the second and third stages.

In SE, it is the loser of the contest who makes a decision in the second stage. It consists of choosing the fraction of his own production that he wishes to destroy. Specifically, loser j selects a "destruction rate" $d_j \in [0, 1]$ which is the fraction of $y - c_j$ that is destroyed and thus unavailable for the winner to appropriate in the third stage. In the third stage the winner learns how much the loser destroyed and thereafter selects a take rate as in the second stage of CS. In other words, a winner i takes a fraction t_i of the production that loser j did not destroy $(1 - d_j)(y - c_j)$.

If there is a contest, the expected earnings of player i in SE are

$$E[\pi_i] = \frac{c_i}{c_i + c_j^e}\left(y - c_i + t_i\left(1 - d_j^e\right)\left(y - c_j^e\right)\right) + \frac{c_j^e}{c_i + c_j^e}\left(1 - t_j^e\right)(1 - d_i)(y - c_i), \tag{4}$$

where c_j^e, t_j^e, and d_j^e are i's expected value for c_j, t_j, and d_j. The first and second elements of the sum are analogous to those of (2).

One can think of this game as representing situations in which players have time between the moment they know they lost the contest and the moment the winner takes control of their resources. As discussed in the introduction, losing parties may in that case be motivated to destroy their production to prevent the winner from enjoying it.

Assuming players are risk neutral own-earnings maximizers one can derive the optimal investment in conflict. Compared to CS, however, the outcome is more ambiguous. The model is again solved by backward induction. In the third stage, a winner i maximizes her earnings by setting $t_i^* = 1$. This makes the loser j indifferent between the different values of d_j. If i thinks j

[4] In order to check whether the differences between our model and these other ones result in markedly different behavior, we ran two additional treatments. In one treatment, we use earnings that are proportional to conflict expenditures, as in Hirshleifer (1988), Skaperdas (1992), and Durham et al. (1998). In the other treatment, we exogenously set $t_i = t_j = 1$ so that, as in Tullock contests, the winner if forced to take all of loser's production. We report the results of these treatments in Section 3.

will chose a destruction rate $d_j^* \in [0,1]$ when indifferent, then i's best reply is

$$c_i\left(c_j\right) = \sqrt{\left(2 - d_j^*\right) y c_j + d_j^* c_j^2} - c_j. \tag{5}$$

If we assume all players hold the same beliefs $d_j^* = d_i^* = d^*$, in the Nash equilibrium the optimal investment in conflict is given by $c^* = \left(\frac{1}{2} - \frac{1}{4}d^*\right) y$. Moreover, if $d^* = 1$ a second Nash equilibrium arises in which $c_i = c_j = 0$ and there is no contest (in this case neither player has an incentive to spend money in conflict given that there is nothing to gain from winning). However, note that if we introduce small perturbations in the actions of players, we do get a unique prediction. That is, as long as there is a small probability $\epsilon > 0$ that the take rate chosen in the third stage is not 1, losers have an incentive to not destroy. In this case, $d^* = 0$ and the optimal investment in conflict is the same as in CS. Namely, half the player's endowment.

2.3 Resistance (RE)

The Resistance (RE) game is also a three-stage game. Again, the first stage of this game is identical to the first stage of CS. Below we describe the next two stages.

The second stage of RE is similar to the second stage of CS in the sense that the winner gets to choose a take rate. However, in this case the take rate determines the fraction that she intends to appropriate *after* the loser has had a chance to destroy his own production in the third stage. In the third stage, the loser learns what the take rate chosen by the winner is and selects a destruction rate, which determines the fraction of his production that is destroyed. Hence, as in SE, a winner i ends up appropriating a fraction t_i of the production that loser j does not destroy $(1 - d_j)(y - c_j)$. Note that, even though in RE and SE players formally have the same expected earnings, which are given by (4), there is an important difference between the two games. Namely, that in RE the loser can condition his destruction rate on the winner's take rate.

The RE game can be thought of as a situation in which winning the conflict gives the winner power to utilize the loser's production, but it does not give her complete control over it. Specifically, after learning how much the winner wants to take (e.g. through taxation) the loser can reduce the amount of appropriable resources (the tax base).

As in CS, we get a clear prediction if we assume own-earnings maximization and risk neutrality. Using backward induction, one can see that a loser j does not gain by choosing a positive destruction rate, thus he chooses $d_j^* = 0$. Given this, the game becomes equivalent to CS where

Table 1: The three games of conflict

	Complete Surrender (CS)	Scorched Earth (SE)	Resistance (RE)
first stage	i and j choose c_i and c_j	i and j choose c_i and c_j	i and j choose c_i and c_j
second stage	i chooses t_i	j chooses d_j	i chooses t_i
third stage	–	i chooses t_i	j chooses d_j
i's earnings	$y - c_i + t_i\,(y - c_j)$	$y - c_i + t_i\,(1 - d_j)\,(y - c_j)$	$y - c_i + t_i\,(1 - d_j)\,(y - c_j)$
j's earnings	$(1 - t_i)\,(y - c_j)$	$(1 - t_i)\,(1 - d_j)\,(y - c_j)$	$(1 - t_i)\,(1 - d_j)\,(y - c_j)$

Note: In all games, the first stage is identical. The winner of the contest is determined by the players' relative expenditures in conflict. See the contest function (1). Moreover, for notational purposes, we assume i wins and j loses the contest in the first stage.

the winner maximizes her earnings by choosing $t_i^* = 1$,[5] and the best reply for investment in conflict is given by (3). It follows that in the Nash equilibrium both players spend half their endowment in conflict.

2.4 Alternative Hypothesis

So far we have described equilibria for the games assuming players are risk-neutral and maximize only their earnings. This is a useful benchmark as it gives us clear predictions. However, there is evidence that these assumptions do not hold in laboratory experiments. For this reason, we briefly discuss the effects of risk-aversion and other-regarding preferences.

Although it has been argued that experimental subjects should behave as if they are risk neutral due to the small stakes involved (Rabin, 2000), there is plenty of evidence from lotteries that individuals can exhibit small-stakes risk aversion (e.g. Holt and Laury, 2002). In the games we consider in this paper, risk aversion increases the equilibrium investment in conflict with the more risk-averse player investing more (Skaperdas, 1991). The basic intuition is that risk-averse players can be seen as being more fearful of losing and therefore they insure themselves against a loss by investing more in conflict. Note, however, that risk aversion does not lead to different behavior in post-conflict stages. Thus, just as with risk neutral players, we should see the same investment in conflict in all three games.

There is also a large amount of evidence suggesting that individuals possess other-regarding

[5] Note that if $t_i = 1$ then the loser is in fact indifferent between any destruction rate $d_j \in [0, 1]$. However, it is clear that only when $d_j = 0$ is this a subgame-perfect equilibrium. Alternatively, one could think that the winner takes $t_i = 1 - \epsilon$ in order to make $d_j = 0$ a dominant strategy.

preferences in the sense that they do not solely maximize their own earnings (Davis and Holt, 1993; Camerer, 2003). In particular, even in anonymous settings with no repeated interaction, people are willing to destroy their own resources in order to sanction another person's unkind or unfair behavior (Güth et al., 1982; Fehr and Gächter, 2000). Furthermore, they are willing to cooperate in social dilemmas as long as others also cooperate (Keser and van Winden, 2000; Fischbacher and Gächter, 2010). Several papers have proposed different motivations as to why this is the case. The most commonly cited are inequality aversion and reciprocity (for a recent review see Fehr and Schmidt, 2006).

In our simplest game, CS, models of other-regarding preferences predict two effects. On one hand, an individual with other-regarding preferences that are strong-enough is willing to cooperate on a purely peaceful outcome if she is certain enough that the other player also possesses strong-enough other-regarding preferences. On the other hand, when facing an opponent without other-regarding preferences, a heightened dislike of being in the loser position or a desire to sanction the other's aggressive behavior motivates individuals with other-regarding preferences to invest more in conflict that individuals with only self-regarding preferences. Thus, whether these models predict more or less investment in conflict depends on the percentage of individual with other-regarding preferences that are strong-enough in the population. For SE and RE these models make a clearer prediction vis-à-vis CS. Since they predict that some of the losers are willing to destroy their production when they expect/face a high take rate, it follows that winning becomes less profitable because of destruction or because winners lower their take rates to avoid destruction. This gives players a smaller incentive to invest in conflict compared to CS.

2.5 Matching procedures and experimental implementation

In the experiment subjects were randomly assigned to one of three treatments. In each treatment subjects played only one of the three games. We thus refer to each treatment according to the game's name. Subjects played the respective game for twenty periods.

In ten of the twenty periods, subjects were rematched such that they faced a different randomly-chosen opponent in every period. We refer to this matching procedure as *Strangers*. The constant rematching and lack of identifiers ought to make Strangers play approximate play in one-shot games. In other words, this is the setting that more closely resembles our theoretical analysis.

In order to investigate the effects of repeated interaction, in the other ten periods, subjects were always matched with the same opponent. We refer to this matching procedure as *Partners*.

This matching procedure allows us to test whether repeated interaction helps subjects overcome the inherent "social dilemma" in games of conflict, and to observe the type of strategies that are most effective in doing so.

In both cases subjects were informed of the matching scheme. To control for sequence effects, half the subjects in each treatment played the ten first periods as Partners and the second ten periods as Strangers. The other half played in the reverse order. Subjects received 1000 tokens as their endowment y in every period. At the end of the experiment two periods (one from each series of ten periods) were randomly selected for payment at an exchange rate of 100 tokens for €1. The experiment was conducted in the CREED laboratory at the University of Amsterdam. In total, 206 subjects participated: 76 in CS, 64 in SE, and 66 in RE. The detailed experimental procedures and the instructions are available in appendix A.

3 Results

In this section we discuss the experimental results. We start by analyzing the subjects' conflict expenditures and their post-conflict behavior in Strangers. Thereafter, we take a look at behavior in Partners, and we investigate what type of repeated interaction leads to peaceful relationships.

Throughout the results section we make pairwise comparisons across treatments and matching procedures. Unless it is otherwise noted, we report p-values of two-sided Wilcoxon-Mann-Whitney tests using individual averages across all periods as independent observations. When testing for the significance of time trends we use Spearman's rank correlation coefficients. Furthermore, since we have multiple treatments and thus we usually run more than one test, we adjust the standard levels of significance $\alpha \in \{0.05, 0.10\}$ using the Benjamini-Hochberg method.[6] We refer to a test as being statistically significant if its p-value is below $\alpha = 0.05$ and as weakly significant if it is below $\alpha = 0.10$ (or the respective adjusted value). When reporting the significance of multiple pairwise comparisons, we indicate the highest p-value when referring to a statistically significant result and the lowest p-value when referring to differences that are not statistically significant (we also report the adjusted value of $\alpha = 0.10$). Given that we found no sequence effects, we report the results using the pooled data.

[6]This reduces the risk of false positives due to multiple testing while controlling for the rate of false negatives (Benjamini and Hochberg, 1995). Since we usually test three hypothesis, this requires ordering the hypothesis H_1, H_2, and H_3 according to their corresponding p-value so that $p_1 \leq p_2 \leq p_3$. Then reject all $H_k, k \leq \bar{k}$ where $\bar{k}$ is the largest k for which $p_k \leq \alpha\frac{k}{3}$.

3.1 Strangers

We start by analyzing the investments in conflict in Strangers. Figure 1A depicts the mean number of tokens invested in conflict over periods for each of the three treatments. We can see that the investment in conflict is highest in CS-Strangers, second-highest in SE-Strangers, and lowest in RE-Strangers. Across all periods, subjects in CS-Strangers invest, on average, 630.72 tokens in conflict. In SE-Strangers they invest 573.00 tokens and in RE-Strangers 456.36 tokens. With pairwise comparisons, we can reject equality of investments across any two treatments ($p = 0.044$, $\alpha = 0.100$). We also observe that mean conflict expenditures increase over time in all treatments. Albeit, we find a significantly increasing trend only in CS-Strangers and RE-Strangers ($p = 0.001$, $\alpha = 0.067$ for CS-Strangers and RE-Strangers and $p = 0.156$, $\alpha = 0.100$ for SE-Strangers).[7]

It is notable that in both CS-Strangers and SE-Strangers mean conflict expenditures are significantly above the 500 tokens one would expect if subjects maximize solely their earnings and are risk neutral (Wilcoxon signed-rank tests, $p < 0.001$, $\alpha = 0.067$). In fact, in these treatments, subjects seem to move *away* from the theoretical benchmark. Thus, unlike in many games where learning moves play closer to equilibrium (e.g. Ho et al., 2007), in this case repetition leads subjects away from it. In RE-Strangers, subjects invest slightly less in conflict than the theoretical benchmark (weakly significant difference, Wilcoxon signed-rank test, $p = 0.056$, $\alpha = 0.100$), but they converge towards it with repetition.

As mentioned in section 2, a high level of conflict expenditures can be the result of subjects being risk averse. In fact, if we assume all subjects possess the same CRRA utility function $U(x) = \frac{1}{1-r}x^{1-r}$, then in CS the equilibrium investment in conflict becomes $c^* = \frac{1}{2-r}y$. Thus, a coefficient of relative risk aversion of $r = 0.415$ could explain the observed mean investment in CS-Strangers. This value for r falls well within the rage of estimates elicited in other experiments. For example, Holt and Laury (2002) estimate $r = 0.319$ with stakes of around $2.40

[7] We find the following results for the additional treatments described in footnote 4. In the treatment where winners are forced to take all of losers' production, mean conflict expenditures equal 686.40 tokens and they significantly increase with repetition ($p = 0.014$, $\alpha = 0.100$). In the treatment where earnings are proportional to expenditures, mean conflict expenditures equal 578.17 tokens and display a positive but not statistically significant trend ($p = 0.176$, $\alpha = 0.100$). Comparing these treatments to CS-Strangers results in expenditures being weakly significantly different ($p = 0.096$, $\alpha = 0.100$). Hence, it appears that compared to a Tullock contest, an endogenously determined prize might reduce conflict expenditures. However, compared to the Hirshleifer (1988) conflict model, the winner-takes-all nature of our model seems to increase conflict expenditures.

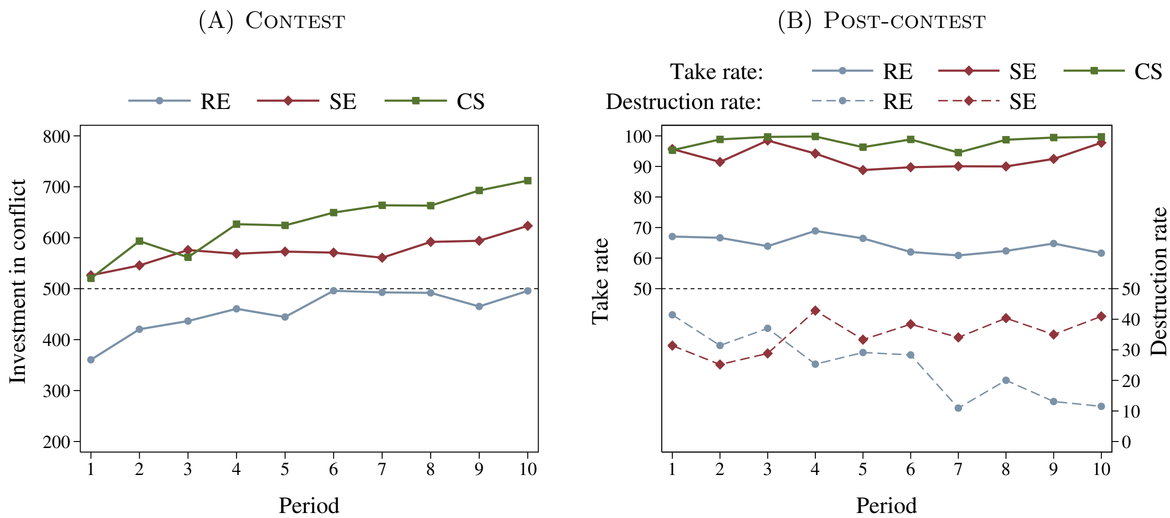

Figure 1: Strangers' conflict and post-conflict behavior

Note: (A) Mean investment in conflict per period for each treatment in Strangers. (B) Mean take rate and destruction rate per period for each treatment in Strangers.

and $r = 0.549$ with stakes of around \$48.50. However, although risk aversion can explain higher overall investment in conflict it provides no explanation as to why these investments differ between treatments. A second explanation for the high investments in conflict is the existence of individuals with other-regarding preferences. However, given that the predictions of models of other-regarding preferences in these games are driven by behavior in post-conflict stages, we postpone the discussion of their predictive power. The finds up to this point are summarized in our first result.

Result 1 Conflict behavior in Strangers

In Strangers, conflict expenditures are relatively high and increases with repetition. Moreover, they vary significantly depending on the post-conflict structure of the game. The lowest conflict expenditures are obtained in Resistance and the highest in Complete Surrender.

The subjects' behavior in the post-conflict stages is summarized in Figure 1B. In the top half of the figure one can see each treatment's mean take rate per period. In the lower half one can see the mean destruction rate of SE-Strangers and RE-Strangers.

Concentrating first on CS-Strangers, one can see that take rates are very close to complete appropriation. Winners take on average 98.11% of the losers production. This figure is very close to the money-maximizing rate of 100%, which is in fact the modal take rate: it is chosen 88.22%

of the time.[8] At 92.90%, average take rates are almost as high in SE-Strangers. Moreover, taking everything is still the modal choice occurring 78.57% of the time. If we compare take rates between SE-Strangers and CS-Strangers, we find they are significantly higher in the latter ($p = 0.008$, $\alpha = 0.100$). Nevertheless, given the small difference in magnitude, one can argue that the intermediate stage in which the loser has the option to destroy has little effect on take rates. Compared to the other treatments, take rates are much lower in RE-Strangers: they average 64.46% (treatment differences are significant at $p = 0.001$, $\alpha = 0.100$). Furthermore, the number of subjects taking everything also drops considerably: it occurs only 4.94% of the time. Thus, giving losers the option to destroy after take rates are chosen does produce a drastic change in taking behavior. To better understand this difference we now turn to the behavior of losers.[9]

In both SE-Strangers and RE-Strangers, a considerable number of subjects are willing to destroy their production. Mean destruction rates are 35.09% in SE-Strangers and 24.85% in RE-Strangers ($p = 0.652$, $\alpha = 0.100$). As with take rates, the modal behavior corresponds to the money-maximizing action of not destroying, which occurs 54.18% of the time in SE-Strangers and 68.21% of the time in RE-Strangers. However, for destruction the opposite action is also relatively common: losers destroy everything 29.77% of the time in SE-Strangers and 20.37% of the time in RE-Strangers. Note that these two actions account for almost all of the losers' choices. In other words, the decision to destroy is almost binary. Lastly, we find a significantly decreasing trend in destruction rates in RE-Strangers ($p < 0.001$, $\alpha = 0.050$) but not in SE-Strangers ($p = 0.400$, $\alpha = 0.100$).

Although mean destruction rates are similar between SE-Strangers and RE-Strangers, there is an important difference between the two. Namely, in RE-Strangers, losers condition their destruction on the take rate of the winner. For example, the Spearman's correlation coefficient between take rates and destruction rates in RE-Strangers is $\rho = 0.45$ ($p = 0.001$, $\alpha = 0.100$).

[8]This is remarkably high compared to dictator games—in which subjects are in an analogous position to that of winners in the sense that they allocate an amount of money between themselves and a second passive player. For example, Forsythe et al. (1994) find that on average dictators take 77.25% of the available money and that only 30.43% take everything. Thus, it appears that winning the contest makes subjects much more willing to take. Interestingly, comparable take rates are seen if dictators have to first earn the money they latter divide. In this case, mean take rates are around 94.71% and 73.77% take all the money (Cherry et al., 2002). Thus, it is possible that winning the contest has a similar effect as earning the money. It seems to make subjects feel entitled to the loser's earnings.

[9]If we check how take rates evolve over time, we find no significant trends in any of the Strangers treatments ($p = 0.193$, $\alpha = 0.033$).

Therefore, winners in RE-Strangers who wish to maximize their earnings are 'forced' to take lower amounts because of the losers' behavior. In fact, the take rate that maximizes earnings is approximately 60% (which implies an average destruction rate of around 20%), which is almost equal to the observed mean take rate.

Result 2 Post-contest behavior in Strangers
In Strangers, take rates are very close 100% in Complete Surrender and Scorched Earth. In contrast, in Resistance they are considerably lower at approximately 60%. Destruction of resources is relatively common and results in a loss of around 30% of the losers' production. Losers usually destroy everything or nothing, and in Resistance they condition their destruction on the winners take rate.

The effect of post-conflict behavior on the return to investment in conflict helps explain the treatment differences in conflict expenditures. In SE-Strangers and RE-Strangers, winning the contest is less profitable than in CS-Strangers. In SE-Strangers this is due to preemptive destruction, whereas in RE-Strangers it is due to either destruction at high take rates or to having chosen a low take rate in the first place. If we take into account that in SE-Strangers losers destroy all their production around 35% of the time, and that in RE-Strangers in order to maximize earnings the winner has to take around 60% (and face a destruction rate of 20%), one would expect the lowest investment in conflict in RE-Strangers, followed by SE-Strangers, and then by CS-Strangers. This is precisely the ordering we see. Therefore, to a large extent, the destruction behavior of losers explains both the differences in take rates and the corresponding differences in conflict expenditures.[10]

In summary, in the Strangers treatments we find high levels of conflict that tend to increase with time (significantly so in CS-Strangers and RE-Strangers). Empowering the loser by giving him the possibility to destroy (part of) his production does reduce conflict levels as it makes winning less profitable. However, we should note that it does not necessarily make subjects better off. Mean earnings per period equal 369.28 tokens in CS-Strangers, 338.30 tokens in SE-Strangers, and 466.54 tokens in RE-Strangers. The difference in earnings between RE-Strangers

[10]Nevertheless, we should point out that although differences in the profitability of conflict explain qualitative differences between treatments in the conflict stage, they fail to explain the magnitude of these differences. For example, for risk neutral players, a reduction in the profitability of conflict of 35% in SE-Strangers and 40% in RE-Strangers ought to translate into an equivalent percentage reduction in conflict expenditures. However, the reduction relative to CS-Strangers is only around 10% in SE-Strangers and 30% in RE-Strangers.

and the other treatments is significant ($p = 0.001$, $\alpha = 0.067$) but that between CS-Strangers and SE-Strangers is not ($p = 0.202$, $\alpha = 0.100$). Hence, only in RE-Strangers is the reduction in conflict expenditures big enough to compensate for the earnings lost due to destruction.

The willingness of individuals to destroy their income has been documented in numerous experiments (Camerer, 2003).[11] For this reason, models of other-regarding preferences, which were created to explain this kind of behavior, can help explain some of the treatment differences. In particular, as mentioned in section 2.4, giving a negative weight to the income of the other player can explain both the losers willingness to destroy and a high investment in conflict.Nonetheless, to the best of our knowledge, current models of other-regarding preferences cannot explain behavior across all *three* treatments unless one changes the models' parameters depending on the game. In particular, it is hard to reconcile the differences in destruction behavior between SE-Strangers and RE-Strangers. If losers correctly anticipate the take rate of the winner in SE-Strangers, they should destroy at the same frequency as in RE-Strangers for comparable take rates. However, we find that they destroy much less in SE-Strangers. For instance, if we look at take rates in the upper quintile in RE-Strangers (which average 87.54%), the mean destruction rate shoots up to 56.73%, which is significantly higher than the mean destruction rate in SE-Strangers where take rates average 92.90% ($p = 0.020$, $\alpha = 0.100$).[12]

3.2 Partners

We next analyze behavior in Partners. Figure 2 shows mean conflict expenditures (A) and post-conflict behavior (B) over time in the Partners treatments. Comparing the three treatments in Partners yields qualitatively similar comparisons as in Strangers.

As in the Strangers treatments, RE-Partners has the lowest mean investment in conflict with 278.07 tokens per period followed by SE-Partners and CS-Partners with 370.64 tokens and 380.66 tokens respectively. Testing for statistical significance reveals that the lower conflict expenditures in RE-Partners are weakly significantly different from those in SE-Partners and CS-Partners ($p = 0.029$, $\alpha = 0.033$). Unlike in Strangers, conflict expenditures in Partners do not exhibit significant trends over time ($p = 0.058$, $\alpha = 0.033$).

[11] For instance, destruction behavior in RE-strangers is very similar to behavior in the power-to-take game, which corresponds to the two post-conflict stages of the RE game. For example, Bosman et al. (2005) report a mean destruction rate of 24.67%, a mean take rate of 59.90%, and a Spearman's correlation coefficient between the two of $\rho = 0.40$.

[12] This same effect has also been found by Gehrig et al. (2007) using variations of ultimatum games.

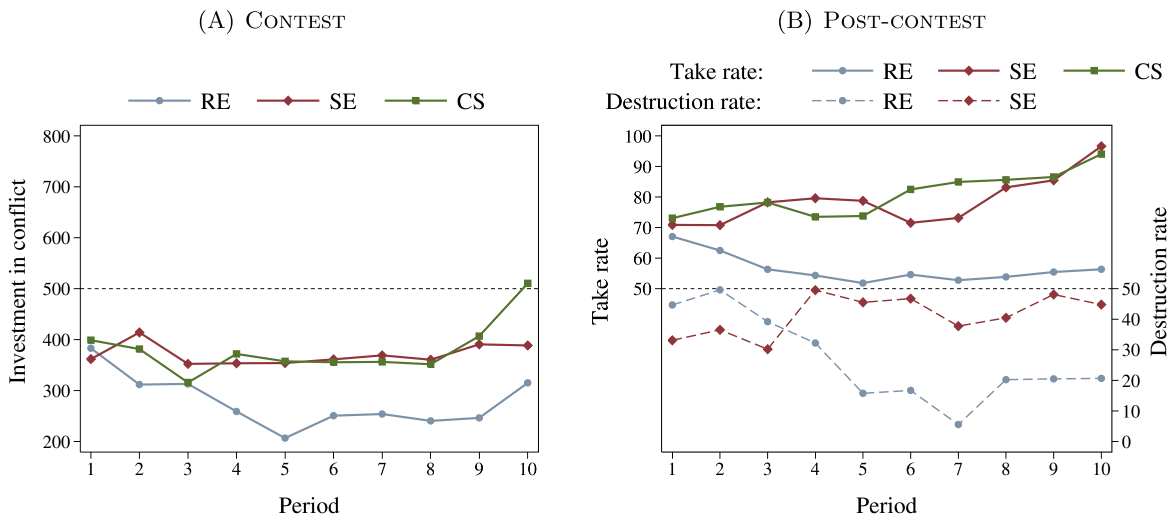

Figure 2: Partners' conflict and post-conflict behavior

Note: (A) Mean investment in conflict per period for each treatment in Partners. (B) Mean take rate and destruction rate per period for each treatment in Partners.

Again, as in the Strangers treatments, mean take rate is highest in CE-Partners at 81.14%, followed closely by SE-Partners at 78.08%, and then well below by RE-Partners at 57.28% (the difference between CS-Partners and SE-Partners is not significant, $p = 0.694$, $\alpha = 0.100$, but that between RE-Partners and the other treatments is, $p = 0.001$, $\alpha = 0.033$). At 40.70%, the mean destruction rate is higher in SE-Partners than in RE-Partners, where it equals 28.32%, but this difference is not statistically significant ($p = 0.643$, $\alpha = 0.100$). We also find that destruction rates significantly decrease with repetition in RE-Partners ($p = 0.001$, $\alpha = 0.050$) but remain constant in SE-Partners ($p = 0.151$, $\alpha = 0.100$). As in Strangers, the decision to destroy is almost binary: subjects destroy nothing or everything 79.8% of the time in SE-Partners and 90.6% of the time in RE-Partners. Moreover, in RE-Partners there is a strong positive correlation between the losers' destruction rate and the winners' take rate (Spearman's $\rho = 0.58$, $p = 0.001$, $\alpha = 0.100$). Unlike in Strangers, mean take rates in Partners do exhibit time trends. We find significantly increasing trends in CS-Partners and SE-Partners and a significantly decreasing trend in RE-Partners ($p = 0.010$, $\alpha = 0.033$).

The more striking differences emerge when we compare conflict expenditures and take rates between Partners and Strangers (cf. Figure 1 and Figure 2). Comparing Partners to Strangers one clearly sees that in all treatments subjects in Partners enjoy lower conflict expenditures ($p = 0.001$, $\alpha = 0.100$) and choose lower take rates ($p = 0.025$, $\alpha = 0.100$). In fact, whereas in

Strangers subjects invest more in conflict than risk-neutral players with self-regarding preferences, in all three Partners treatments mean conflict expenditures are below the 500-token benchmark (Wilcoxon signed-rank tests, $p = 0.002$, $\alpha = 0.100$). The next result summarizes these findings.

Result 3 Behavior in Partners

Conflict expenditures and take rates are considerably lower in all treatments in Partners compared to Strangers. However, the differences between Complete Surrender, Scorched Earth, and Resistance are qualitatively similar.

3.3 Achieving peace

As was mentioned in Result 3, Partners in all treatments show lower levels of conflict than Strangers do. Interestingly, this is mostly due to their ability to coordinate on the peaceful outcome and avoid conflict altogether. In Partners, the percentage of periods in which there is no contest because both players invest zero in conflict is 26.32% in CS-Partners, 27.50% in SE-Partners, and 31.82% in RE-Partners. In contrast, in Strangers the highest percentage is 2.63% in RE-Strangers. In this section we analyze how Partners manage to achieve peace.

The first thing one notices when looking at peaceful periods is that they are highly concentrated in a few groups. This can be seen in Figure 3, which shows the percentage of groups that attain a given number of peaceful periods in Partners (for all treatments). Remarkably, the majority of groups (58.25%) do not have one single peaceful period. In fact, the majority of peaceful periods is concentrated in a few groups: 35.93% of the groups have five or more periods of peace and account for 93.86% of all peaceful periods. Moreover, the frequency of peaceful groups seems to be independent of the treatment. For example, there is no statistically significant difference between treatments in the frequency of groups that never achieved a period of peace (pairwise Fisher's exact tests, $p = 0.157$, $\alpha = 0.033$).

Compared to Strangers, groups in Partners that never achieve peace no longer display considerably lower conflict expenditures. Their mean investment in conflict is 544.66 tokens in CS-Partners, 565.64 tokens in SE-Partners, and 480.05 tokens in RE-Partners (recall, in Strangers the investment is 630.72 tokens in CS-Strangers, 573.00 tokens in SE-Strangers and 456.36 tokens in RE-Strangers). Compared to the corresponding treatment in Strangers, these groups no longer have significantly lower conflict expenditures in SE-Partners and RE-Partners ($p = 0.575$, $\alpha = 0.067$). In CS-Partners conflict expenditures are still significantly lower ($p = 0.003$, $\alpha = 0.033$) albeit the difference with CS-Strangers is now much smaller.

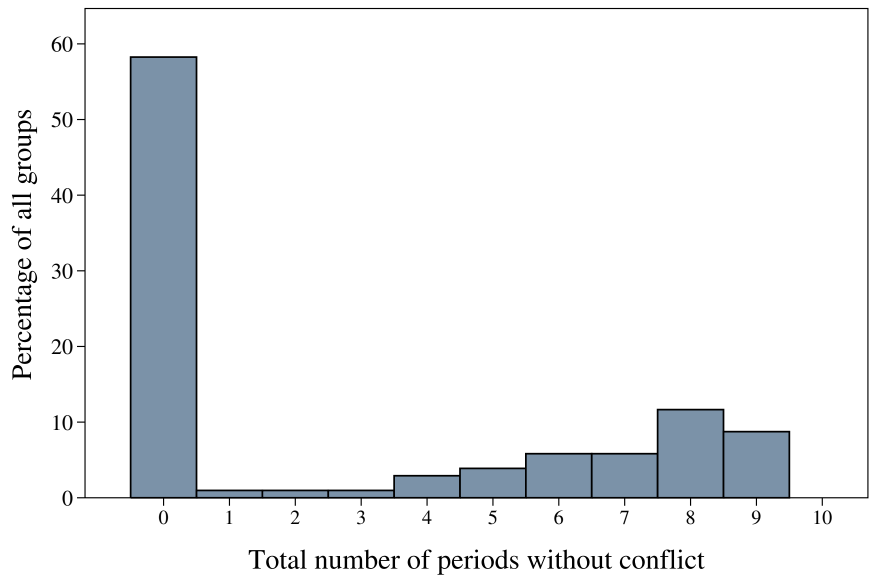

Figure 3: Frequency of peaceful periods by group

Note: The histogram shows the percentage of groups that attain a given number of peaceful periods. All treatments in Partners are included.

The second thing one notices is that once peace is reached, it is remarkably stable. For example, in 87.94% of the time a peaceful period is followed by another peaceful period, and if we exclude the last period to avoid end-game effects this increases to 94.80%. This can also be seen in Figures A1 through A3 in the appendix, where the investment in conflict of each group member in each group is plotted.

Therefore, to understand the main difference between Partners and Strangers we explore why some groups manage to reach a long-lasting peaceful relationship while others do not. Some of the groups are lucky enough to start a peaceful relationship already in the first period (23.26% of those who obtain at least one period of peace). Thus, knowing *ex ante* that they will interact with the same opponent for some time already produces a significant number of peaceful groups. However, the majority of peaceful relationships are attained after a few periods in which conflict did occur. To observe how these groups overcome their initially aggressive interaction and eventually attain peace, we analyze behavior in periods preceding the first period of a peaceful relationship.

In *all* cases, the first period of a peaceful relationship is preceded by a period in which one of the two players did not invest in conflict. In fact, choosing not to fight in a given period leads to peace in the following period in 15.69% of the cases in CS-Partners, 23.26% in SE-Partners, and

Table 2: Attaining peaceful relations

Probit regressions with an dummy variable that equals 1 if subjects i and j achieve their first peaceful period in period $t+1$ and 0 otherwise as the dependent variable.

	CS	SE	SE ($d=0$)	RE
Investment in war	-0.095	-0.081	-0.283	-0.254
	(0.53)	(0.28)	(0.49)	(1.36)
Low take rate	0.169**		0.591**	0.062
	(2.00)		(2.19)	(0.32)
High destruction rate		0.051		0.019
		(0.40)		(0.12)
Period	-0.051***	0.007	0.008	-0.068*
	(3.20)	(0.25)	(0.15)	(1.78)
Prediction at $\bar{x}$	0.08	0.25	0.19	0.27
Pseudo R^2	0.27	0.01	0.28	0.09
# Obs	47	40	16	54

Note: We utilize observations in which $w_j = 0$ and $w_i > 0$ in period $t \in [0, 9]$, and under partners matching. All independent variables are for period t. Marginal effects at mean values are reported. Numbers in parenthesis are z-values calculated with robust standard errors and clustering by group White (1980). Asterisks indicate significance at the 1% (***), 5% (**), and 10% (*) level.

28.07% in RE-Partners (there is a weakly significant difference between CS-Partners and RE-Partners, $p = 0.030$, $\alpha = 0.033$). This pattern is similar to those in various coordination games where subjects who end in the payoff-dominant equilibrium usually start in the risk-dominant one. This is accomplished if one of the players makes the costly move of playing the payoff-dominant action (see Camerer, 2003). However, unlike in coordination games, in our conflict games players can also use their post-conflict actions to further signal or confirm their desire to coordinate on peace.

We investigate the role of two particular post-conflict actions in facilitating peace. First, given that a subject who chooses not to invest in conflict automatically loses the contest if the other does not do the same, a natural way for the winner of the contest to confirm future peaceful intentions is to chose a low take rate. Second, after not having invested in conflict, the loser can use destruction as a way of punishing the winner for investing a positive amount and to signal that there is nothing to gain from fighting. To test the effectiveness of these two actions, we run Probit regressions with a dependent variable that equals one if a pair of subjects i and j achieve peace in period $t+1$ and zero otherwise. We look at cases in which j does not invest in conflict in period t. As independent variables from period t, we use: i's conflict expenditures, a dummy variable indicating whether i's take rate is below the median (60%), and a dummy variable indicating whether j's destruction rate is above the median (70%). Since achieving peace is more profitable in earlier periods, we also include the period number. Lastly, given that it does not make sense to signal willingness to act peacefully when the game is about to end, we exclude observations from the final period of the game. We run a regression for CS-Partners and RE-Partners and two regressions for SE-Partners. In the first SE-Partners regression we include the dummy variable for a high destruction rate to determine whether destruction promotes peace. In the second SE-Partners regression, in order to to isolate the effect of the take rate, we use only periods in which there is no destruction and include the dummy variable for a low take rate. We use two regressions in SE-Partners because when losers destroy all their production they leave the winners with no choice at all. This makes impractical the simultaneous estimation of the two effects. The results are presented in Table 2. Note that we report the marginal effects of the coefficients at the mean values.

The results indicate that in CS-Partners, choosing a low take rate considerably improves the probability of reaching a peaceful outcome in the next period (it increases it by 16.9%). The effect is even stronger in SE-Partners (an increase of 59.1%), although in this case, the decision to take a small amount is conditioned on the loser choosing not to destroy all his production. In RE-Partners we do not find that choosing a low take rate facilitates future peace.[13] The reason for this difference can be that in CS-Partners and SE-Partners choosing a low take rate is an unambiguously kind action whereas in RE-Partners a low take rate can be chosen for selfish reasons (i.e. because the winner thinks the loser will destroy if she takes too much). Unlike low take rates, neither choosing a high nor a low destruction rate is conducive to peace. Hence, for the purpose of attaining a peaceful relationship, destruction as a form of punishment is simply a cost that does not produce any benefits. In both CS-Partners and RE-Partners, the period number has a negative and significant coefficient indicating that peaceful relations are more likely to be formed in early periods. These and the previous findings are summed up in our last result.

Result 4 ATTAINING PEACE

[13]This is not due to the lower take rates of RE-Partners. We get the same result if we define the dummy for a low take rate as less than the median take rate in RE-Partners or as a take rate in RE-Partners's lower quartile.

Long-lasting peaceful relationships are attained when parties expect a long future interaction. Moreover, for peace to be attained after there has been conflict, one of the parties must signal her peaceful intentions by choosing not to invest in conflict. Players can also signal peaceful intentions by choosing low take rates if by doing so they incur a cost. Finally, the use of destruction as punishment does not lead to future peaceful outcomes.

4 Conclusions

An important characteristic of the extended conflict games that we study in this paper is that players can avoid the contest in the first phase of the game altogether by not investing any resources in conflict. Furthermore, different behavioral options after the contest and the possibility of repeated interaction with the same opponent are allowed to affect investment in conflict and the frequency at which groups can reach long-lasting peaceful relationships.

We find that, in the absence of repeated interaction (Strangers setting), investment in conflict is not only considerably higher than the standard theoretical benchmark (as has been frequently observed in rent-seeking experiments) but also increases over time. Moreover, we observe that differences in the post-contest structure of the games result in significantly different effects on conflict expenditures, which cannot be explained if one assumes that players maximize solely their monetary earnings. In particular, if given the choice to destroy some of their production, many defeated players prefer to do so rather than let the winner of the contest take it away from them. Given the willingness of losers to destroy, winning a contest becomes less profitable and leads subjects to invest less in conflict and focus more on their own production. However, due to the destruction of production, lower conflict expenditures do not always lead to higher earnings. Nevertheless, the most profitable setting is not Complete Surrender (where the winner can appropriate whatever he likes) but the Resistance game where the profitability of winning is curbed by the threat of destruction which (in contrast with Scorched Earth) can be conditioned on the claim made by the winner of the contest. As the loser has to carry out this threat only occasionally less production is wasted.

Given the role of destruction it is important to understand what the motivational driving factors are for destruction in both the Scorched Earth and the Resistance treatments. To shed light on this question, we gathered self-reported data of the subjects' emotions.[14] We find

[14]During the experiment, at the end of periods 1, 10, and 20, losers in Scorched Earth and Resistance were asked to self-report their experienced emotions when making the destruction decision. Subjects used seven-point scales to

that losers of a contest who destroy everything in Scorched Earth report significantly higher intensities of fear and lower intensities of hope compared to losers who do not destroy ($p < 0.001$, $\alpha = 0.02$). In contrast, in Resistance, losers who destroy report significantly higher intensities of contempt and irritation ($p < 0.003$, $\alpha = 0.02$). In other words, in Resistance, destruction is correlated with aggressive emotions triggered by a hurtful act perceived as intentional. This is consistent with the literature on emotions and the punishment of unfair or unkind actions (for a review, see van Winden, 2007). In contrast, in Scorched Earth it is correlated with the anticipatory emotions of fear and hope, which are triggered by expectations (Ortony et al., 1988). This illustrates that decision-making is different when punishing an action that already took place compared to punishing an expected action, which has not yet occurred.We also find that repeated interaction with the same opponent produces a strong and significant reduction in conflict expenditures. Interestingly, this reduction is mostly explained by the emergence of long-lasting peaceful relationships in about one third of all groups, often after substantial conflict. It turns out that in order to overcome conflict and attain peace, one of the parties must signal with a costly action her willingness to stop fighting. The most important signal in this respect appears to be refraining from any investment in conflict, which implies a certain loss of the contest. In addition, appropriating little when this unambiguously implies giving up income also serves as a signal for peace. In contrast, using destruction as a punishment device does not seem to promote peaceful relationships. We leave it as an important task for future research to establish how peace can be engineered in case of multiple opponents.

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report how intensely they felt the following emotions: anger, contempt, excitement, fear, gratitude, hope, irritation, pride, regret, and shame.During the experiment, at the end of periods 1, 10, and 20, losers in Scorched Earth and Resistance were asked to self-report their experienced emotions when making the destruction decision. Subjects used seven-point scales to report how intensely they felt the following emotions: anger, contempt, excitement, fear, gratitude, hope, irritation, pride, regret, and shame.

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A Supplementary Materials

A.1 Experimental procedures

The computerized experiment was conducted in 2006 in the CREED laboratory at the University of Amsterdam. Subjects were recruited through the CREED recruitment website and the experiment was programmed with z-Tree (Fischbacher, 2007). The experiment lasted around 1 hour. In total, 206 subjects participated in the experiment.

The number of subjects in each treatment and sequence of play is summarized in Table A1. As can be seen, subjects played in one of the three treatments and one of the two matching sequences. Subjects played repeatedly for 20 periods. Periods 1 to 10 under the first matching type and periods 11 to 20 under the second one. In each period, subjects received 1000 tokens as their endowment. At the end of the experiment two periods (one for each matching) were randomly selected for payment. Average earnings, including a €2.50 showup fee, were €16.69 (1000 tokens equaled €10).

After arrival in the lab's reception room, each subject drew a card to be randomly assigned to a seat in the laboratory. Once everyone was seated, subjects were given the instructions for the experiment (see below). Subjects were told that the experiment consisted of two independent parts. We emphasized the fact that their choices in the first part will not affect their earnings

Table A1: Experimental treatments

	Sequence	
Treatment	Partners - Strangers	Strangers - Partners
Complete surrender	38 subjects	38 subjects
Resistance	32 subjects	34 subjects
Scorched Earth	32 subjects	32 subjects

in the second part. Thereafter, subjects had to answer a few exercises in order to check their understanding of the game to which they had been assigned. Next, they played 10 periods of the respective game via the computer. At the end of the first part, instructions were distributed concerning the second part of the experiment. They consisted of informing subjects they would play precisely the same game for 10 more periods but with a different matching procedure. After finishing the second part, subjects answered a debriefing questionnaire after which they were paid in private and dismissed.

During the game subjects were asked to provide their expectations of the other player's actions. They were asked after subjects made their own choice but before they were informed of the choice of the other. Furthermore, at the end of periods 1, 10, and 20, subjects were asked to self-report their experienced emotions. In all treatments, winners were asked to report their feelings when making their take rate decision. Moreover, in SE and RE losers reported their feelings when making their destruction decision. We asked subjects to self-report in 7-point scales the following emotions: anger, contempt, excitement, fear, gratitude, hope, irritation, pride, regret, and shame.

Below is a sample of the instructions used in the experiment. It corresponds to the Resistance treatment in which subjects first played under the strangers matching scheme. After playing for 10 rounds, subjects where told they would play again the same game but with a different matching scheme. At that point they were given the opportunity to read the instructions once again. Instructions for other treatments and for partners matching are very similar and available upon request.

A.2 Instructions

Welcome to this experimental session on decision making. In this session, you can earn money. How much you earn depends on your decisions and the decisions of other participants. In addition and thus independent of your earnings in the experimental session - you will receive a show-up fee of 2.50 euro. The session has two different experiments. The earnings of each experiment are independent. At the end of the session you will be paid your earnings of each experiment plus the show-up fee privately (one by one) and in cash in euros.

During the experimental session you must be quiet and not communicate with other participants. If you have a question, please raise your hand. We will then come to your table to assist you.

Neither during nor after the experiment will others be informed of your actions or of you answers to any questions. Since your answers will be linked to your table number, but not to your name, anonymity is assured also with respect to the analysis of the experimental session.

Instructions for the first part of the experiment

This experiment consists of 10 rounds of decision making. In each round, you will be matched into a pair with one other participant. This other participant will be a different person for all the 10 rounds. In each round the computer will randomly determine whom you will be matched with. For convenience, we will sometimes call this other participant 'Other'.

At the beginning of each round, both you and the participant you are paired with (Other) will get 1000 tokens to earn money with. At the end of the experimental session, one of the rounds will be randomly selected for paying out. The earnings of that round, together with the show-up fee, will then be paid out.

Each round will consist of four phases. In phase 1, you and Other will have to allocate the 1000 tokens that each of you have received to two projects. In phase 2, there will be a lottery, based on the allocation of tokens. In phase 3, the winner of the lottery will have to choose a percentage. Finally, in phase 4, the loser of the lottery will have to choose a percentage. We will now discuss these phases in detail.

Phase 1: Allocation of tokens to two projects

In this phase, you as well as Other will have to allocate the 1000 tokens that each of you received to two projects: project P1 and project P2. Any distribution of tokens is allowed, including putting all tokens in only one project. Tokens put into P1 (P1-tokens) directly lead to earnings, whereas tokens put into P2 (P2-tokens) will give a chance to get earnings, as will be explained next.

Project P1:

For tokens put into P1 it holds that: 100 tokens = 1 euro in earnings. Thus, each token allocated to P1 generates earnings of 1 eurocent.

Project P2:

This project concerns a lottery. The tokens that you and Other put into P2 will determine your and Others chances of winning this lottery. Whoever is the winner of this lottery will have to choose a percentage in phase 3. This percentage determines the share of the P1-tokens of the loser of the lottery that will go to the winner. This is further explained below. Whoever is the loser of this lottery will have to choose a percentage in phase 4. This percentage determines the share of the P1-tokens of the loser of the lottery that will be destroyed. This is also further explained below. We will now show how the chance of winning the lottery is determined. Your chance of winning is determined by your share in the total number of tokens in P2:

$$\text{Your chance of winning} = \text{Your P2-tokens} \;/\; (\text{Your P2-tokens} + \text{Others P2-tokens})$$

Similarly, Others chance of winning is determined by Others share of the tokens in P2. Thus, the chances for you and Other together always sum up to 100%. For example, suppose that you put 200 tokens in P2 and Other puts 800 tokens in P2. Your chance of winning the lottery then equals: $200/(200+800) = 200/1000 = \frac{1}{5}$ (20%), whereas Others chance of winning equals: $800/1000 = \frac{4}{5}$ (80%).

For any given number of tokens that Other will put into P2, your chance of winning increases the more tokens you put into P2 yourself. In our example, if you would have put 800 in P2, instead of 200, your chance of winning would have become: $800/(800+800) = 800/1600 = \frac{1}{2}$ (50%).

Clearly, the chance of winning will always be 50% if both you and Other put the same number of tokens in P2. However, you will not know Others decision when you make your own decision. Once you and Other have decided you will be informed about each others decision regarding the allocation of tokens to P1 and P2.

Note that there will be no lottery if neither you nor Other puts any tokens in P2. In that case phases 2, 3 and 4 will not take place, the round ends here and your earnings at the end of this round amount to 1000 tokens from your P1-tokens (10 euros).

Phase 2: Lottery, based on tokens in P2

In this phase, the computer will perform the lottery, based on the tokens put into P2, to select and announce the winner.

Phase 3: Winner of lottery chooses a percentage

In this phase, only the winner of the lottery must make a decision, which consists of choosing a percentage. This percentage determines the share of the P1-tokens of the loser of the lottery that will be transferred to the winner. The percentage must be an integer between 0 and 100. Also the values 0 and 100 are allowed. After the winner of the lottery has chosen the percentage, this decision will be known by the loser of the lottery. Also for the tokens obtained by the winner in this way it holds that: 100 tokens = 1 euro.

Phase 4: Loser of lottery chooses a percentage

In this phase, only the loser of the lottery must make a decision, which consists of choosing a percentage. This percentage determines the share of the P1-tokens of the loser of the lottery that will be destroyed. The percentage must be an integer between 0 and 100. Also the values 0 and 100 are allowed. Also for the tokens destroyed by the loser in this way it holds that: 100 tokens = 1 euro.

Example of determination of earnings in a round

We illustrate with an example how earnings in a round are determined. Suppose that, in phase 1, you put 400 tokens in project P1 and 600 tokens in project P2, while Other (the participant you are paired with) puts 800 tokens in P1 and 200 in P2. This means that your chance of winning the lottery equals $600/(600+200) = \frac{3}{4}$ (75%), while Others chance equals $\frac{1}{4}$ (25%). Furthermore, assume that the outcome of the lottery, in phase 2, shows that you are the winner. Assume next that, in phase 3, you decide that 60% of the P1-tokens of Other are to be transferred to you. Assume next that, in phase 4, Other decides that 50% of her or his P1-tokens are to be destroyed. The transfer from Other to you is then equal to 240 tokens (60% of 400 tokens).

Since 100 tokens are worth 1 euro, your earnings at the end of this round then amount to: $400/100 = 4$ euro (from your P1-tokens) plus $240/100 = 2.40$ euro (via the transfer from Other), which amounts to $4 + 2.40 = 6.40$ euro earnings in total.

Others earnings in this example amount to: $800/100 = 8$ euro (from Others P1-tokens) minus $400/100 = 4$ euro (due to the destruction) minus $240/100 = 2.40$ euro (due to the transfer to you), which amounts to $8 - 4 - 2.40 = 1.60$ euro earnings in total.

Summary

There will be 10 rounds of decision making. In each round you will be randomly and anonymously paired with one other participant who will be a different person for all the 10 rounds. Furthermore, each round consists of four phases.

In phase 1, both you and the participant you are paired with will get 1000 tokens to allocate to two projects, P1 and P2. Each token put in P1 earns 1 eurocent (1 euro per 100 tokens). Tokens put in project P2 determine the chance of winning the lottery in phase 2. The winner of this lottery decides in phase 3 which percentage of the P1-tokens of the loser (of the lottery) is transferred to her or him (the winner). This decision will be known by the loser of this lottery. Next the loser of this lottery decides in phase 4 which percentage of her or his P1-tokens is destroyed. There will be no lottery if you as well as the participant you are paired with allocate 0 tokens to P2. In that case the round ends after phase 1.

At the end of the experimental session one of the rounds will be randomly selected to be paid out. The earnings from that round will be paid out in private and in cash.

To make you fully familiar with the determination of your earnings, we will shortly ask you to answer some questions. If you want, you can now look again into these Instructions. When you are ready, please click on [ready].

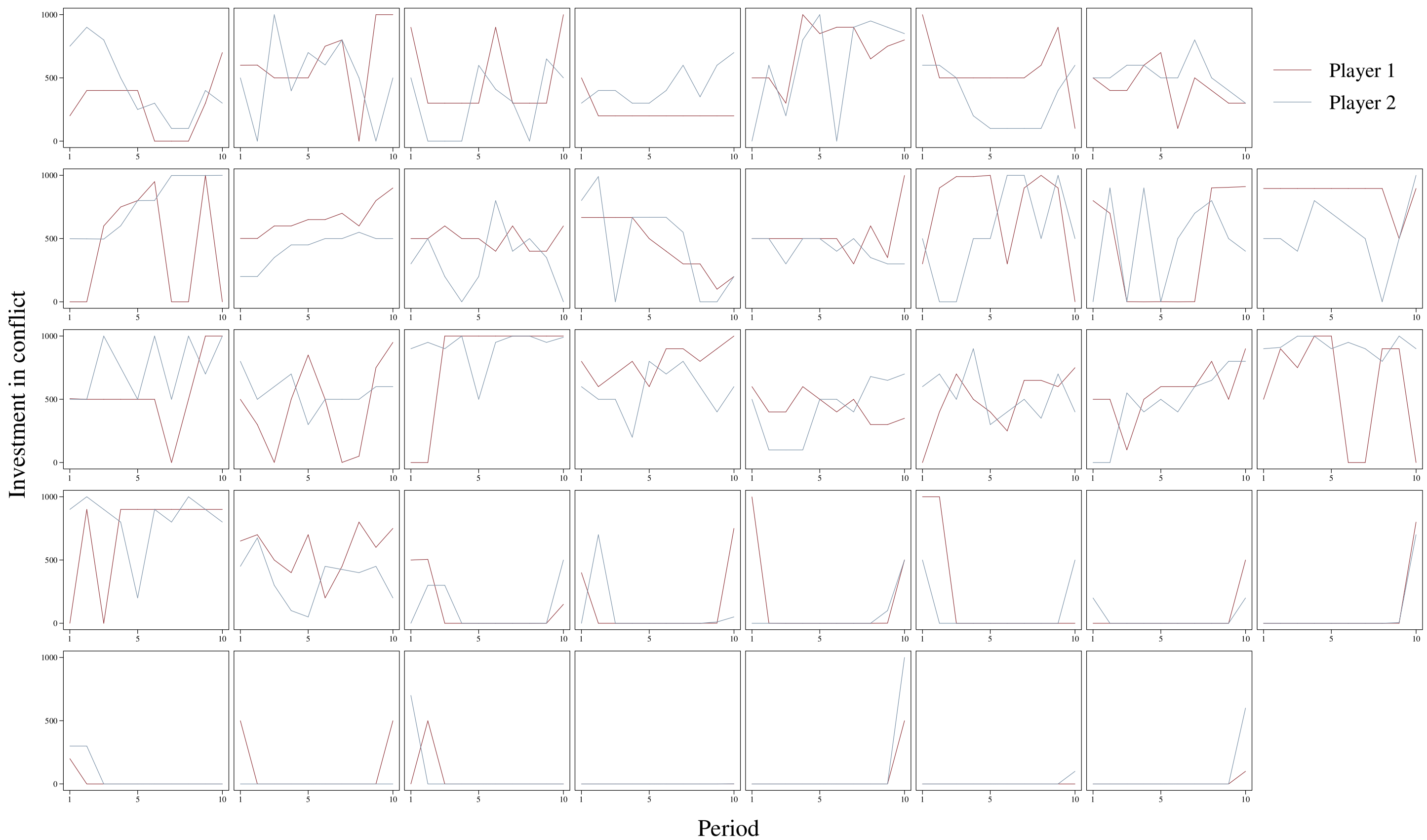

Figure A1: Conflict expenditures per subject in each group in CS-Partners

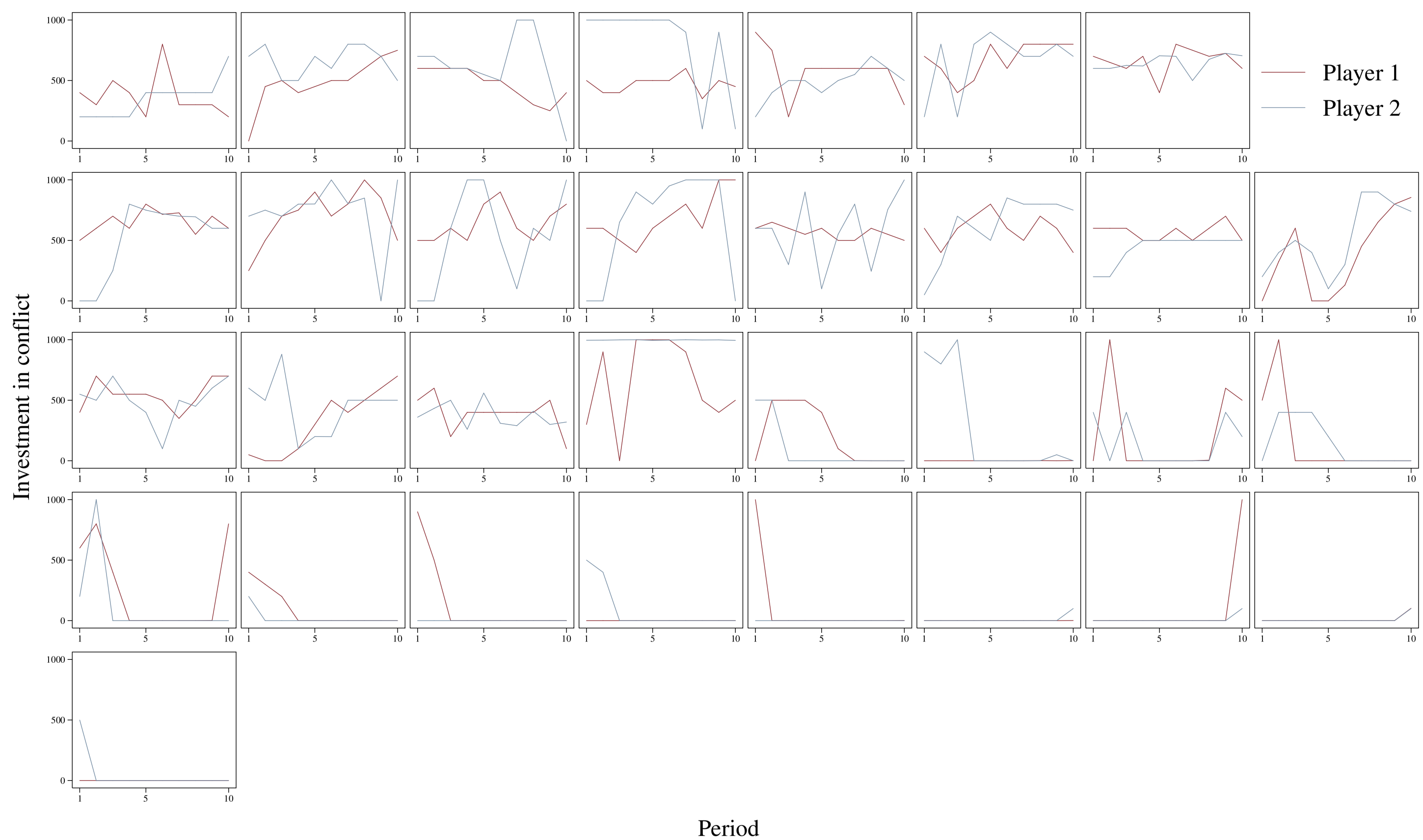

Figure A2: Conflict expenditures per subject in each group in SE-Partners

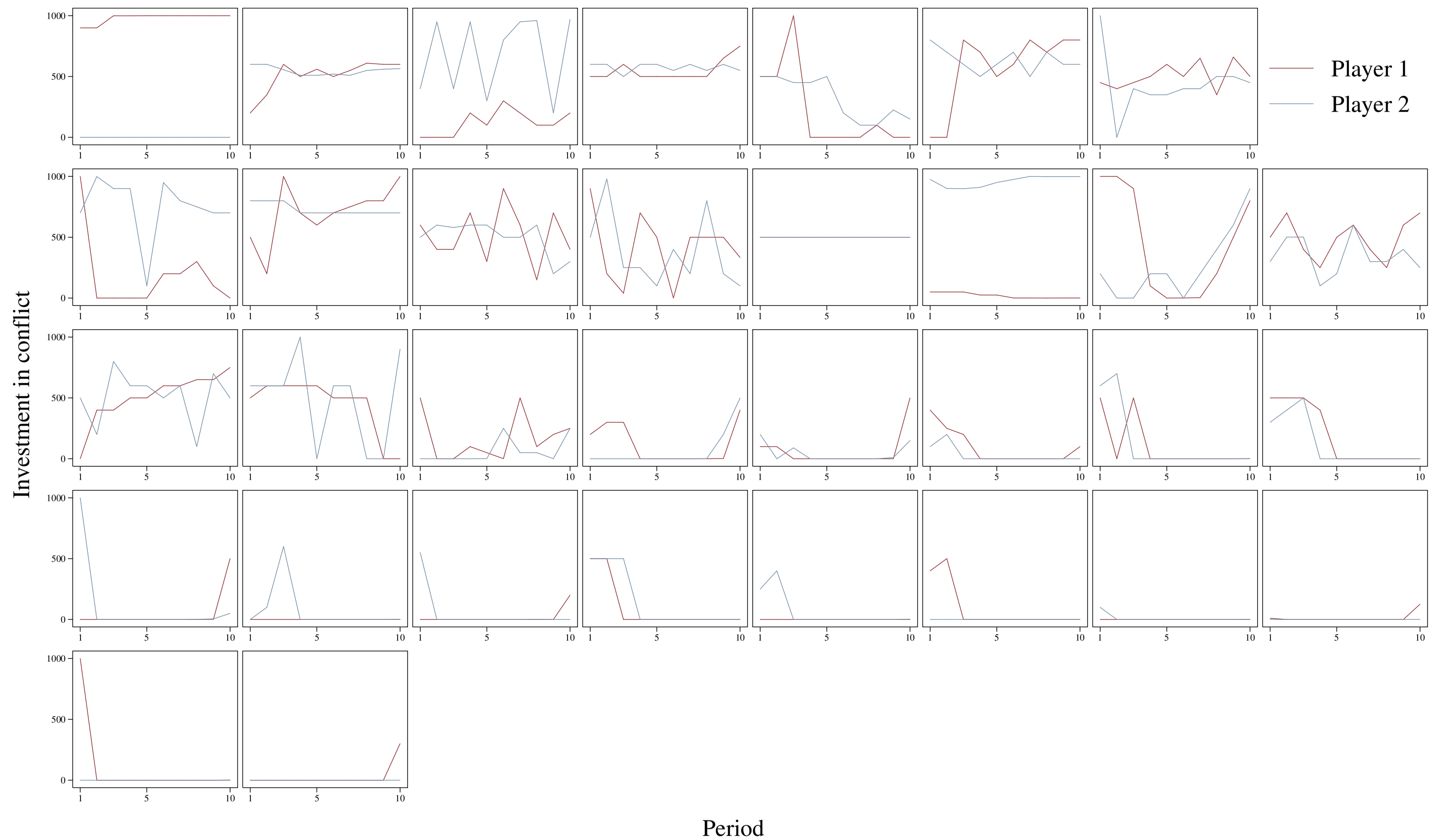

Figure A3: Conflict expenditures per subject in each group in RE-Partners