

After the War: An experimental study of post-conflict behavior

Juan A. Lacomba*

Francisco M. Lagos†

Ernesto Reuben‡

Frans van Winden§

Abstract

Most models of conflict concentrate on how players allocate resources between productive and fighting efforts. After a conflict, the winner is assumed to take control of all the resources of the loser. In this paper we show experimentally that this simplification misses an important component of a conflict, namely the reaction of the defeated player. We find that, if given the choice to destroy some of their resources, many defeated players prefer to do so rather than let the winner take any of it. Given this behavior, incentives to invest in weapons as opposed to production change and in some cases lower levels of conflict are achieved. Furthermore in settings with repeated interaction, the behavior of players in post-conflict stages can serve as a form of costly communication which enables players to reach a peaceful outcome in the future.

This version: December 2007

*University of Granada and Lineex

†University of Granada and Lineex

‡Northwestern University

§University of Amsterdam and CREED

1 Introduction

In order to calculate the profitability of engaging in armed conflict it is necessary to know the probability of winning and the amount resources one can extract from the defeated party if one is victorious.¹ In order to calculate the latter one must have an idea of how the defeated party will react in the post-conflict stage. Hostility towards the winner or pride may motivate the loser to destroy resources that would have otherwise been appropriated by the winner, making the initial conflict less profitable. The aim of this paper is to investigate this kind of post-conflict behavior, which is essential for our understanding conflict in general.

For this purpose, we extend the models of Hirshleifer (1988, 1991) and Skaperdas (1992) in which two players allocate an initial resource between productive and appropriative efforts. The relative investments in the latter determine the winner of the conflict which keeps of the loser's production. We build on their model by introducing post-conflict stages in which the winner chooses how much to take from the loser and the loser chooses how much of his own resources to destroy.

We consider three different variations. The first we refer to as *Complete Surrender*. In it, we introduce one post-conflict stage where the winner decides how much to take of the loser's production as opposed to automatically receiving all of it. This second stage might be relevant if winners wish to retrain themselves out of fairness considerations or as a way to signal willingness to avoid future wars. This case also serves as a benchmark for the other two variations.

In our second variation, called *Resistance*, there is an additional third stage where the loser, once he knows the amount the winner wishes to take, decides how much of his production to destroy. This game can be considered analogous to cases in which part of the production of the loser depends on labor, thus even if defeated, the loser can reduce his effort and limit the amount of production that the winner can appropriate. Behaviors such as this has been observed in several occasions: the French resistance in the Second World War is a good example.

In the third variation, which we refer to as *Scorched Earth*, the second and third stages of the previous game are reversed. In other words, in the first post-conflict stage the loser decides how much production to destroy, and thereafter, in the second post-conflict stage, the winner decides how much to appropriate. This type of destruction has been carried out in numerous occasions. Examples include the Kuwaiti oil fires started by the Iraqi military forces in 1990 when they were driven out by the United States and Hitler's order to destroy all of Germany's

¹See, e.g., Skaperdas, 1992, 1996; Hirshleifer, 1988, 1989, 1991; Garfinkel, 1990; Grossman, 1991; among others. For an excellent survey of this line of research see Garfinkel and Skaperdas, 2006.

productive resources once he know he had lost the war.²

We study the three games by conducting a laboratory experiment. The experimental approach can be particularly illustrating in this case as it allows us to control type the post-conflict actions available, the probabilities of winning, and the endowments of the parties. Furthermore, given than destruction behavior is not well understood, an experiment allows us to study it without imposing assumptions concerning why people destroy their own resources. In fact, an important contribution of the paper is precisely to shed light in this type of actions.

We test our three post-conflict scenarios under *strangers* matching, where subjects are randomly paired each period, and under *partners* matching, where subjects are stay with the same partner throughout the experiment. With the latter condition we aim at studying how groups manage to avoid continuous violence, and the role post-conflict behavior has in promoting peace.

There exists a large and recent literature related to the economics of conflict. It's focus has been mainly the analysis of the trade-off between producing goods (productive activities) and weapons (appropriative activities). The aim of most of the papers in this literature is to study the optimal investment in weapons and how it is affected by altering parameters such as risk aversion (Skaperdas, 1991), the existence of future interaction (Skaperdas and Syropoulos, 1996), the optimal amount of weapons when there are both offensive and defensive types (Grossman and Kim, 1996), the possible equilibrium when the conflict is costly (Neary, 1996), etc. All these papers consider that the case in which the game ends after the conflict is resolved and assume the winners keeps all of the losers productive resources.

There are few experimental papers dealing with conflict. Durham et al. (1998) test the Hirshleifer's model of power. They examine how changes in the technology of conflict affects productive activities and under what conditions is the "Paradox of Power" (the poorer contender improves her position relative to the richer, Hirshleifer, 1991) is observed. Carter and Anderton (2001) test Grossman and Kim's (1996) predator-prey model. They find that increases in the relative effectiveness of predation against defense leads to changes in the equilibrium amount of predation. Duffy and Kim (2005) test a model of anarchy where subjects must repeatedly choose whether they want to be predators or producers. They study whether individuals follow "career paths" or instead switch between types.

The paper is divided as follows. In section 2 we describe the games and the experimental design in detail. In section 3 we present the experimental results. Section 4 concludes.

²This strategy was also used by Russian army both against Napoleon in the 19th century as against Hitler in the 20th century.

2 The Experiment

In the experiment, three different variations of the conflict games studied by Hirshleifer (1988), Skaperdas(1992), and others were played. Subjects participated in only one of the three games. Next we describe each game, a 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 w_i of their resource to “weapons”, thus leaving $y - w_i$ to “production”. The relative amount of weapons determines the probability of winning. Specifically, we use a special case of the commonly-used function in the conflict literature where the probability of winning is given by³

$$p_i(w_i, w_j) = \frac{w_i}{w_i + w_j} \text{ if } w_i + w_j > 0. \quad (1)$$

As can be seen, if both players spend equal amounts in weapons then they have an equal probability of winning the conflict. Furthermore, a player i 's probability of winning $p_i(w_i, w_j)$ increases with her expenditures in weapons w_i and decreases with their opponent's w_j .

Unlike the majority of the literature, which considers conflict to be unavoidable, we allow players to avoid fighting by choosing $w_i = 0$. If both players spend zero resources in weapons then there is no conflict and the game ends. In this case both players receive earnings of y . If at least one of the players spends a positive amount then the game continues into the second stage.

At the beginning of the second stage a winner is determined according to (1). In this stage the winner decides how much of the losers production to appropriate. Specifically, winner i choses a “take rate” $t_i \in [0, 1]$ which is the fraction of $1 - w_j$ that she wishes to claim. The loser makes no decision.

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

$$E[\pi_i] = \frac{w_i}{w_i + w_j^e} (y - w_i + t_i(y - w_j^e)) + \frac{w_j^e}{w_i + w_j^e} (1 - t_j^e) (y - w_i), \quad (2)$$

³In the more general functional form, all instances of w_i and w_j are raised to the power of $m > 0$. This so-called “effectiveness parameter” can be interpreted as the degree of uncertainty in the determination of the winner. Thus, in this paper, we consider the less certain case where $m = 1$ and a player's probability of winning equals the proportion of her weapons expenditures relative to the total. See Hirshleifer (1989) and Skaperdas (1996) 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.

where w_j^e and t_j^e are i 's expected value for w_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 amount of weapons. The model is solved by backward induction. In order to maximize her earnings a winner i chooses $t_i^* = 1$. Given this, one can maximize (2) and obtain the best reply of i :

$$w_i(w_j) = \sqrt{2yw_j} - w_j. \quad (3)$$

Solving for the symmetric Nash equilibrium of the game gives us the optimal amount of weapons expenditures.⁴ Namely, for both players to spend half of their endowment in production and the other half in weapons, which implies that both players have a $\frac{1}{2}$ probability of winning. This equilibrium is the same as the simplest case of Durham et al. (1998).

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. Unlike in CS, the loser of the conflict also makes a decision.

In SE, after the winner of the conflict is determined, it is the loser 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 $1 - w_j$ that is destroyed and thus unavailable for the winner to appropriate in the third stage.

In the third stage the winner learns what the destruction rate chosen by the loser is. Thereafter she selects a take rate as in the second stage of CS. In this case, for a winner i , t_i is the fraction of the production not destroyed, $(1 - d_j)(1 - w_j)$, that she wants to appropriate.

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

$$E[\pi_i] = \frac{w_i}{w_i + w_j^e} (y - w_i + t_i (1 - d_j^e) (y - w_j^e)) + \frac{w_j^e}{w_i + w_j^e} (1 - t_j^e) (1 - d_i) (y - w_i), \quad (4)$$

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

⁴It is straightforward to see that $w_i = w_j = 0$ is not a Nash equilibrium. In this case both contenders have an incentive to increase their weapons expenditures, win the conflict with certainty, and take all their rival's production.

One can think of this game as a case in which players have some time between the moment they know they lost the conflict and when the winner is able to take control of the productive assets. As mentioned in the introduction, there are numerous examples of losers destroying their production to prevent the winner from enjoying it even though doing so might infuriate the winner and potentially make the loser worse off once the winner takes over.

Again, assuming players are risk neutral own-earnings maximizers one can derive predictions as to the optimal amount of weapons, although in this case they are somewhat 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 actually makes the loser indifferent with respect to his destruction rate choice. If we assume that losers choose a commonly known destruction rate $\bar{d} \in [0, 1]$ then the best reply of a player i is

$$w_i(w_j) = \sqrt{(2 - \bar{d})yw_j + \bar{d}w_j^2} - w_j. \quad (5)$$

In the symmetric Nash equilibrium the optimal amount of weapons expenditures is given by $w^* = (\frac{1}{2} - \frac{1}{4}\bar{d})y$. Although, if $\bar{d} = 1$ a second equilibrium arises in which $w_i = w_j = 0$ and there is no conflict (in this case neither player has an incentive to spend money on weapons given that there is nothing to gain from winning).

Note that, if we introduce small perturbations in the actions of players we do get a unique prediction. 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, $\bar{d} = 0$ and the optimal amount of weapons is the same as in CS. Namely, half the players' endowment.

2.3 Resistance (RE)

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

The second stage of RE is very similar to the second stage of CS in the sense that in it the winner chooses a take rate. However, in this case the take rate is the fraction of the loser's production *after the third stage* that she appropriates.

In the third stage the loser is communicated the take rate chosen by the winner and then selects a destruction rate. As in SE, the destruction rate is the fraction of the loser's production that he destroys and therefore cannot be taken by the winner. In other words, a winner i , receives only a fraction t_i of the production that loser j does not destroy $(1 - d_j)(1 - w_j)$.

Table 1: The three games

Note: In all games, the 1st stage is identical. The winner of the contest is determined by the players' relative expenditures in weapons, see (1).

	Complete surrender	Scorched Earth	Resistance
1 st stage	players chose weapons expenditures w	players chose weapons expenditures w	players chose weapons expenditures w
2 nd stage	winner i chooses take rate t_i	loser j chooses destruction rate d_j	winner i chooses take rate t_i
3 rd stage	–	winner i chooses take rate t_i	loser j chooses destruction rate d_j
Earnings of winner i	$y - w_i + t_i(y - w_j)$	$y - w_i + t_i(1 - d_j)(y - w_j)$	$y - w_i + t_i(1 - d_j)(y - w_j)$
Earnings of loser j	$(1 - t_i)(y - w_j)$	$(1 - t_i)(1 - d_j)(y - w_j)$	$(1 - t_i)(1 - d_j)(y - w_j)$

Note that, even though in RE the second and third stages are reversed with respect to SE, the expected earnings are identical and given by (4). The difference being that in RE the loser can condition his destruction on the winner's chosen 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 capacity but it does not give her complete control over it. Specifically, after learning how much the winner wants to take (e.g. by taxing) the loser can produce at less than full capacity.

As in CS we get a clear prediction if we assume own-earnings maximization and risk neutrality. Using backward induction, one can see that for a given t_i a loser j does not gain by choosing a positive destruction rate, thus he chooses $d_j^* = 0$.⁵ Given this, the game becomes equivalent to CS in which the winner maximizes her earnings by choosing $t_i^* = 1$, the best reply for weapons expenditures is equal to (3), and in the symmetric Nash equilibrium both players spend half their endowment in weapons.

2.4 Experimental design

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

⁵Note 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 the only subgame-perfect equilibrium is that in which $d_j = 0$. Alternatively one could think of as the winner taking $t_i = 1 - \epsilon$ in order to make $d_j = 0$ a dominant strategy.

Subjects played the respective game for 20 periods. In 10 of those periods subjects played with the same opponent. In the other 10 periods subjects were rematched such that they played with a randomly chosen opponent in every period. In both cases subjects were informed of the matching scheme. Throughout the paper we refer to the first matching scheme as *partners* and to the second as *strangers*. In order to control for sequence effects half the subjects in each treatment played the 10 first periods as partners and the second 10 periods as strangers whereas for the other half it was the other way around.

Subjects received 1000 tokens as their endowment y in every period. At the end of the experiment two periods were randomly selected for payment at an exchange rate of 100 tokens for 1 euro. 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, including the instructions used are available in Appendix A.

3 Results

In this section we discuss the experimental results. First, we analyze at the aggregate level the differences between treatments in weapons expenditures. Second, we study the subject's post-conflict behavior to help explain treatment differences in the first stage. Third, we perform an individual-level analysis of how expenditures in weapons change over time. Lastly, we investigate how some groups manage to maintain a peaceful relationship whereas others do not.

Throughout the results section when making comparisons across treatments and matching schemes, unless it is otherwise noted, we report p -values of two-sided Wilcoxon-Mann-Whitney tests. We apply individual averages across all periods as independent observations. Furthermore, since in most cases run various tests to compare the three treatments to each other we adjust p -values using the Bonferroni-type adjustment due to Benjamini and Hochberg (1995).⁶ Given that we found no sequence effects, we report the results using the pooled data.

3.1 Conflict behavior

We start analyzing the decision to allocate resources to weapons under strangers' matching. Figure 1A depicts the average number of tokens spent on weapons over periods for each of the three treatments. We can see that weapons expenditures are highest in CS, second-highest in SE, and lowest in RE. Across all periods, subjects in CS spend, on average, 631 tokens in weapons. In SE they spend 573 tokens and in RE 456 tokens. We can reject equality of distributions

⁶For three tests the adjustment is to multiply the lowest p -value by three, and the second-lowest by two.

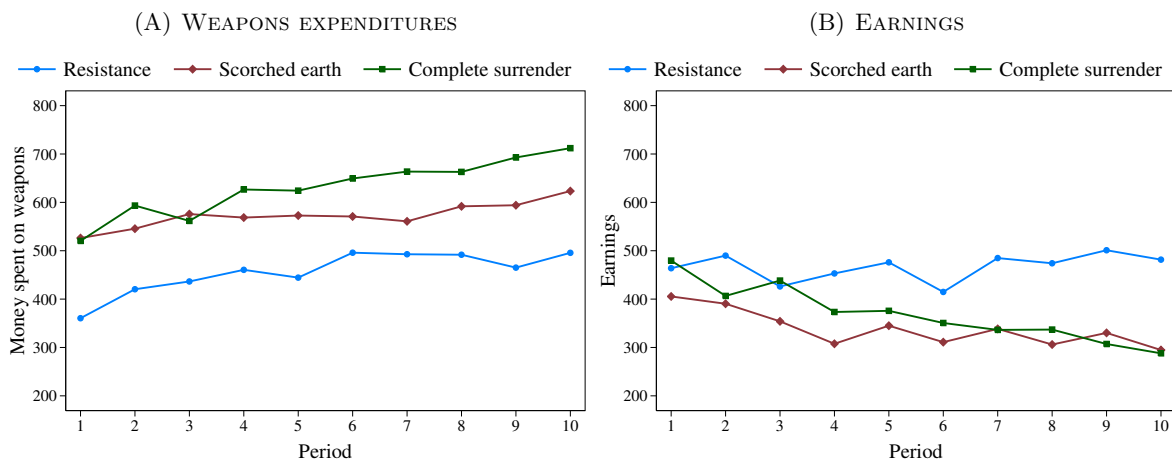


Figure 1: Strangers' weapons expenditures and earnings

Note: (A) Mean weapons expenditures per period for each of the three treatments when groups are rematched every period. (B) Mean earnings per period for each of the three treatments when groups are rematched every period.

across all treatments ($p < 0.044$). In all cases we observe that weapons expenditures increase over time. Albeit, we find a significantly increasing trend only in CS and RE (Spearman's ρ , $p < 0.002$ for CS and RE and $p = 0.156$ for SE).

It is notable that in both CS and SE weapons expenditures are considerably above the 500 tokens one would expect if subjects maximize solely their monetary income and are risk neutral (Wilcoxon signed-rank tests, $p < 0.001$). 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 subjects spend less in weapons than the theoretical benchmark (Wilcoxon signed-rank test, $p = 0.056$) although they appear to converge to 500 with time.

If we look at earnings, we see that in RE they are the highest with an average of 466 tokens. CS and SE have very similar earnings at 369 tokens and 338 tokens. The difference in earnings between RE and the other treatments is significant ($p < 0.002$) but that between CS and SE is not ($p = 0.202$). In Figure 1B one can also see how earnings evolve over time. Checking for significant trends shows a weakly significant decrease in earnings in CS and no significant change in SE and RE (Spearman's ρ , $p = 0.056$, and $p > 0.592$). Again, note that earnings do not conform to the theoretical benchmark. In this case they are below the expected 500 tokens in all treatments (Wilcoxon signed-rank test, $p < 0.075$).

Next we turn to decisions under partners' matching. Figure 2A shows the average weapons expenditures over time in each treatment. As for strangers, RE has the lowest amount of resources spent in conflict. For partners, CS and SE have very similar levels of weapons.

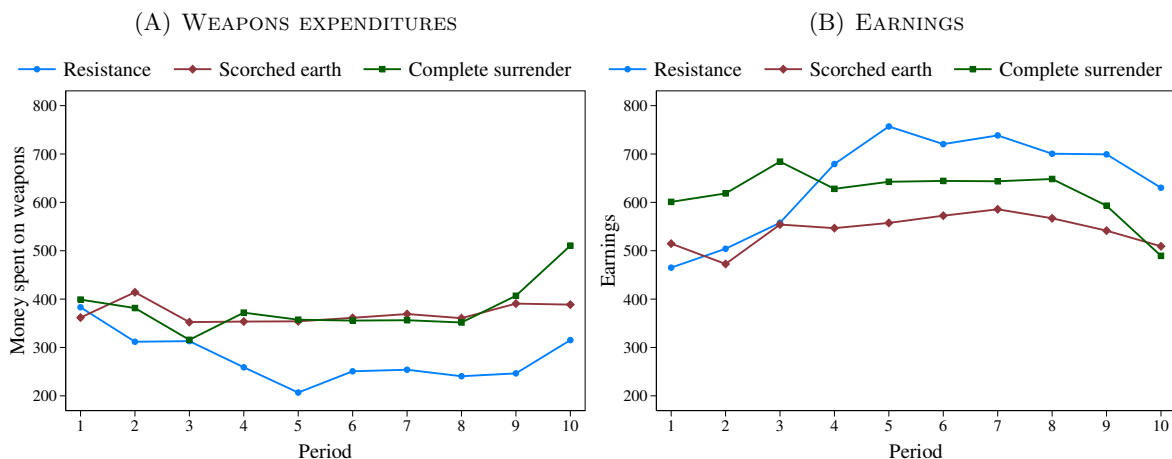


Figure 2: Partner’s weapons expenditures and earnings

Note: (A) Mean weapons expenditures per period for each of the three treatments when groups remain the same across periods. (B) Mean earnings per period for each of the three treatments when groups remain the same across periods.

Overall, subjects spend per period 381 tokens in CS, 371 tokens in SE, and 278 tokens in RE. Testing for statistical significance we find that the lower weapons in RE compared to the other treatments is weakly significant ($p < 0.086$) and no difference between CS and SE ($p = 0.998$). Unlike strangers, weapons expenditures under partners matching do not exhibit a significant trend over time (Spearman’s ρ , $p > 0.172$).

Average earnings for partners display the same ordering as for strangers: 645 tokens in RE, 619 tokens in CS, and 542 tokens in SE. However, in this case the differences are not statistically significant ($p > 0.119$). As can be seen in Figure 2B, earnings increase over time in RE (Spearman’s ρ , $p < 0.001$), particularly in the first five periods of play. They remain more or less constant in CS and SE (Spearman’s ρ , $p > 0.280$).

Comparing partners and strangers one clearly see that partners enjoy lower weapons expenditures and higher earnings ($p < 0.001$). Whereas strangers tend to spend more fighting than theory would predict, in all three treatments under partners’ matching average weapons expenditures are below 500 tokens (Wilcoxon signed-rank tests, $p < 0.003$). Similarly, earnings in CS and RE, but not in SE, are significantly higher than 500 tokens (Wilcoxon signed-rank tests, $p < 0.002$ and $p = 0.254$).

Interestingly, the better performance of partners is mostly do to their ability to avoid fighting altogether. For partners’ matching, the percentage of periods in which there is no conflict due to both players choosing to spend zero tokens in weapons is 26.3% in CS, 27.5% in SE, and 31.8% in RE. Overall much higher than for strangers where the highest percentage was 2.6% in RE. If we look at periods in which there is conflict, the advantage of partners almost disappears. For

example, they no longer have significantly higher earnings in SE and RE ($p > 0.330$) although it is still the case in CS ($p < 0.001$). We address this more in detail in Section 3.4.

Note that, since the only differences between treatments are the post-conflict stages, we can attribute to them the differences in weapons expenditures. In the next section we study behavior in these stages in order to better understand the subjects' decisions in the conflict stage.

3.2 Post-conflict behavior

The subjects' behavior in the second and third stages is summarized in Figure 3. On the top half of the graphs one can see the average take rates chosen by the winners of the conflict in each period for each treatment. In the lower half one can see the average destruction rates chosen by the loser in SE and RE.

If we concentrate first in CS, we can see that under strangers' matching, take rates are very close to complete appropriation. In this case winners take on average 98.1% of the losers production. This figure are very close to the money maximizing rate of 100%, which is in fact the modal take rate: it is chosen 88.2% of the time. This is remarkably high if we compare it to games in which subjects are in a similar position to the winners in this treatment: that is, dictator games.⁷ For example, Forsythe et al. (1994) find that on average dictators take 76% of the available money and that only 30% take everything. These figures drop if one uses double-blind procedures (in these case take rates average 91% and 64% of dictators take everything, Hoffman et al., 1994), however they still do not reach the levels we see in CS. It appears that winning the conflict makes subjects more willing to take. Perhaps because they feel entitled to the loser's money.

Comparing behavior in CS between strangers and partners, it is clear that with an average of 81.1%, take rates are significantly lower under partners ($p < 0.001$). It is also the case that winners are less likely to take everything. Take rates of 100% occur only 58.3% of the time. If we check how take rates evolve over time, we find a significantly increasing trend for partners and no trend for strangers (Spearman's ρ , $p < 0.001$ and $p = 0.193$).

Take rates are almost as high in SE. The average take rate is 92.9% under strangers and significantly lower at 78.1% under partners. Taking everything is still the most common choice in both matching schemes however it is considerably higher for strangers. Take rates of 100% occur 78.6% of the time under strangers and 41.2% of the time under partners. As in CS,

⁷In the dictator game subjects simply decide how to allocate an amount of money between themselves and a second passive player.

we find no change in take rates over time for strangers and a significantly increasing trend for partners (Spearman's ρ , $p = 0.739$ and $p = 0.003$).

Comparing take rates in SE to CS, we find that under partners take rates are not significantly different ($p = 0.694$). For strangers we find that they are significantly higher in the latter treatment ($p = 0.017$). Nevertheless, given the small difference in magnitude between take rates, it appears safe to conclude that the intermediate stage in which the loser has the option to destroy has little effect on take rates.

Overall, destruction behavior in SE is similar under both matching schemes. Average destruction rates are 35.1% for strangers and 40.7% for partners. These values are not significantly different from each other ($p = 0.378$). As with take rates, the modal behavior corresponds to the money-maximizing action of not destroying: this occurs 54.2% of the time under strangers and 47.1% under partners. However, in this case the opposite behavior is also relatively common. Under strangers, losers destroy everything 29.8% of the time, and under partners they do so 32.6% of the time. Note that these two actions account for almost all the losers' behavior. In other words, the decision to destroy is quite binary. We do not find in either matching scheme a significant trend in destruction rates over time (Spearman's ρ , $p > 0.151$).

In contrast to other treatments, take rates are much lower in RE. They average 64.5% under strangers and 57.3% under partners (the former being significantly higher $p < 0.026$). The number of subjects taking everything also drops considerably: it occurs only 4.9% of the time under strangers and 7.2% under partners. As one might expect, average take rates are significantly lower in RE compared to the other treatments ($p < 0.001$ for both matching schemes). Although in both matching schemes take rates seem to decrease slightly over time, only for partners is this a significant trend (Spearman's ρ , $p = 0.341$ and $p = 0.010$).

As in SE, a considerable number of subjects are willing to destroy their production. On average, under strangers losers destroy 24.9% of their production and under partners they destroy 28.3% (these values are not significantly different, $p = 0.643$). Again, the decision to destroy is mostly a binary one with no destruction being the most common choice. Strangers do not destroy 68.2% of the time and destroy everything 20.4% of the time. For partners the respective percentages are 67.3% and 23.3%. Under both matching schemes we find a significantly decreasing trend in destruction (Spearman's ρ , $p < 0.001$).

Notably, behavior in RE is very similar to behavior in games where subjects are in an equivalent position to that of the winner (but without the fighting stage). For instance, in the power-to-take game,⁸ Bosman et al. (2005) report an average take rate of 60.0% and a

⁸The power-to-take game corresponds to the last two stages of the RE treatment but with roles randomly

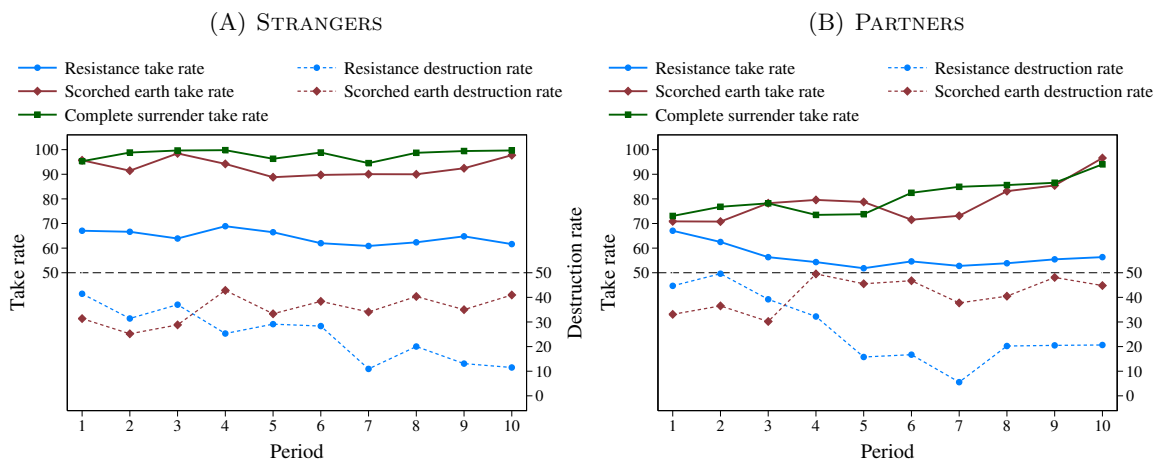


Figure 3: Take and destruction rates

Note: (A) Mean take rates and destruction rates per period for each of the three treatments when groups are rematched every period. (B) Mean take rates and destruction rates per period for each of the three treatments when groups remain the same across periods.

destruction rate of 24.7%.

The willingness of losers to destroy their resources at high take rates explains why winners in RE chose to take lower amounts. In this treatment, losers strongly condition their destruction on the take rate of the winner. For example, the pairwise correlation coefficient between take rate and destruction rate is for 0.457 strangers and 0.576 for partners. In fact, given the losers' behavior, if one is solely interested in maximizing the amount taken, one should take around 60%.

Note that this makes destruction remarkably different across RE and SE. If losers correctly anticipate the take rate of the winner in SE and were as sensitive to take rates as in RE, they would destroy much more than they currently do. For instance, if we look at destruction at take rates above 75% in RE (note that this cutoff is below the average take rate in SE), destruction rates shoot up to 55.1% under strangers and 71.3% under partners. Both these take rate are significantly higher than the respective average take rate in SE ($p < 0.013$). As pointed out by Gehrige et al. (2007), this might be due to individuals being unwilling to punish an action that has not been taken yet.

To some extent, behavior in the post-conflict stages helps explain the subjects' initial choice of weapons expenditures. Since winning the conflict under SE and RE implies a lower amount taken from the loser (in SE due to destruction and in RE due to destruction or a low take rate), it explains why weapons expenditures in these treatments are lower than in CS. In fact, if we take into account that losers destroy everything around 30% of the time in SE and that assigned.

to maximize earnings the winner ought to take rate around 60% one would expect the least amount of weapons in RE, followed by SE, and then by CS. This is precisely the ordering we see in both matching schemes (albeit for partners the difference between CS and SE is not significant). Moreover, the fact that there is destruction also explains why, in spite of lower weapons expenditures, earnings are not higher in SE compared to CS. In RE the decrease in destruction rates over time is consistent with earnings not deteriorating in spite of an increasing trend in weapons expenditures under strangers, and of earnings increasing in spite of constant weapons expenditures under partners.

Nevertheless, we should point out that although differences in post-conflict behavior explain the qualitative differences between treatments in the conflict stage, they fail to explain the magnitude of these differences. A limitation to take 30% to 40% less ought to translate into an equivalent reduction in weapons expenditures. However, the reductions we observe are only around half of what one would predict.

3.3 The dynamics of conflict

In this section we investigate how subjects determine the amount sent on weapons. In particular we investigate how they adjust their expenditures depending on what happened in previous periods.

For the analysis we run an OLS regression for each treatment and matching scheme. The dependent variable in all cases is the change in weapons expenditures from period $t-1$ to period t by subject i : $\Delta w_{i,t} - w_{i,t-1}$.⁹ As our first explanatory variable we use an indicator variable measuring whether subject i was the winner of the contest in the previous period (Win_i). This allows us to check if winning per se produces a change in weapons expenditures. The second explanatory variable is the difference in weapons expenditures between the winner and the loser of the contest in the previous period. Thus if i was the winner this variable equals $w_i - w_j$ and otherwise $w_j - w_i$. For notational purposes we use the subscript m to refer to the winner of the conflict in $t-1$ and n to denote the loser. Thus, our second explanatory variable is $w_m - w_n$. It would be natural to think that losers will tend to increase their weapons expenditures and the more so the bigger the difference in previous expenditures. Winners on the other hand would tend to decrease their expenditures. To take this asymmetry into account, our third variable interacts $w_m - w_n$ with Win_i . As the fourth explanatory variable we use the total amount spent in weapons by both players in the previous period ($w_m + w_n$). This allows us to see if subjects behave differently after more aggressive (passive) periods. As our fifth variable we use the take

⁹We use random effects regression to allow for a subject-specific error terms.

rate implemented in the previous period (t_m), it is either the take rate chosen by i (if i won) or the one faced by i (if i lost). Note that in SE we do not observe a take rate if the loser destroys everything. In this cases we set $t_m = 0$. Our sixth explanatory variable corresponds to the implemented destruction rate in the previous period (d_n). It equals i 's destruction rate (if i lost) or the one faced by i (if i won). Finally, in the reported regressions, we also include all significant interaction variables.

Given that in this section we are interested in how previous conflict shapes the subjects' current expenditures in weapons, we utilize observations from periods in which there is conflict and that are preceded by a period in which conflict also occurred. In order to avoid a large number of decimal places, we normalize weapons expenditures so that 1000 tokens equal 1. The resulting regressions are presented in Table 2.

The strongest effect on the change of weapons expenditures is the difference in expenditures between the winner and the loser of the previous period. It is clear by the coefficient of $w_m - w_n$ in all treatments and matching schemes that if i just lost she strongly increases her weapons expenditures and she does so more if the previous difference in expenditures was high. On the other hand, if i won in the previous period she reduces her weapons expenditures (the sum of coefficients of $w_m - w_n$ and $\text{Win}_i \times w_m - w_n$ is negative and significant in all regressions, Wald tests $p < 0.001$). In some cases, namely in CS and RE under strangers the loser effect dominates such that for a given difference the increase for the loser is bigger than the decrease of the winner (Wald tests, $p < 0.049$). In RE under partners it is the winner effect the stronger one (Wald tests, $p = 0.002$), and in the remaining treatments they are not significantly different (Wald tests, $p > 0.464$). Note also that in both matching schemes the magnitude of both the winner and loser effect is smaller in RE compared to CS and SE. We also see throughout an effect of the total amount of weapons expenditures. Higher amounts are associated with a decrease in weapons expenditures in the next period. Finally, having won the previous contest has a negative effect on expenditures in CS and RE under strangers.

The explanatory variables related to post-conflict behavior also have an effect on weapons expenditures. In all cases, higher take rates in the previous period are related to higher current weapons expenditures. This is true for both chosen and experienced take rate in CS and RE. In SE, a high take rate is followed by more weapons expenditures if it is experienced as a loser and not if it is chosen as a winner (Wald test for the later, $p > 0.921$). The effect of take rates makes sense since learning that one can take a large amount if one wins or lose it if one loses makes players want to spend more in the conflict. Destruction rates have an effect only in RE under partners. In this case, a high destruction rate is associated with more weapons expenditures by the loser.

Table 2: Dynamics of conflict

Note: Regressions with the change in weapons expenditures from period $t - 1$ to period t by subject i as the dependent variable. We utilize observations from periods in which there is conflict and are preceded by a period with conflict. One regression per treatment and matching scheme is presented. In all cases weapons expenditures are normalized so that 1000 tokens equals 1. All independent variables refer to the period $t - 1$. We use the subscript m to refer to the winner of the conflict in $t - 1$ and n to denote the loser. Win_i is an indicator variable that equals one if $i = m$ and zero otherwise. $w_m - w_n$ is the difference in weapons expenditures between m and n . $\text{Win}_i \times w_m - w_n$ equals $w_i - w_j$ if $i = m$ and zero otherwise. $w_m + w_n$ is the total expenditures in weapons. $\text{Win}_i \times w_m + w_n$ equals $w_i + w_j$ if $i = m$ and zero otherwise. t_m is the take rate chosen by m (in SE n might destroy everything leaving m with no choice, in these cases we set t_m to zero). $\text{Win}_i \times t_m$ equals t_i if $i = m$ and zero otherwise. d_n is the destruction rate chosen by n . $\text{Win}_i \times d_n$ equals d_j if $i = m$ and zero otherwise. $d_n \times t_m$ interacts these two variables. OLS regressions with subject random effects. Standard errors are in parentheses. The symbols *, **, *** indicate statistical significance at the 10%, 5%, and 1% level.

	<i>Strangers</i>			<i>Partners</i>		
	CS	SE	RE	CS	SE	RE
Win_i	-62.48*** (18.41)	119.38* (67.59)	-172.37*** (40.15)	-29.21 (28.51)	80.65* (41.71)	19.68 (32.35)
$w_m - w_n$	400.53*** (34.76)	336.89*** (41.61)	252.70*** (35.90)	464.89*** (53.64)	340.96*** (57.40)	113.37** (51.06)
$\text{Win}_i \times w_m - w_n$	-575.31*** (48.58)	-628.61*** (58.41)	-374.48*** (49.61)	-821.84*** (75.77)	-736.22*** (80.26)	-485.96*** (71.73)
$w_m + w_n$	-207.36*** (25.52)	-158.26*** (36.46)	-232.78*** (28.81)	-294.45*** (30.37)	-148.28*** (27.18)	-208.83*** (32.77)
$\text{Win}_i \times w_m + w_n$		-82.36* (51.40)	158.69*** (40.03)			
t_m	157.82* (83.39)	116.18** (48.51)	80.53* (46.67)	251.21*** (47.71)	142.42** (55.86)	278.69*** (104.32)
$\text{Win}_i \times t_m$		-110.13*** (38.35)			-136.89** (56.97)	
d_n		4.51 (44.90)	-9.10 (18.88)		28.36 (43.00)	268.95** (109.27)
$\text{Win}_i \times d_n$						-149.86*** (54.68)
$d_n \times t_m$						-393.38** (157.54)
Constant	142.64 (87.32)	135.99** (60.89)	183.27*** (36.34)	109.20** (49.15)	71.66 (56.20)	45.61 (57.02)
R^2	0.338	0.338	0.254	0.342	0.278	0.234
Wald χ^2	313.97***	269.64***	195.72***	300.21***	152.84***	160.05***
# Obs	622	538	582	446	404	388

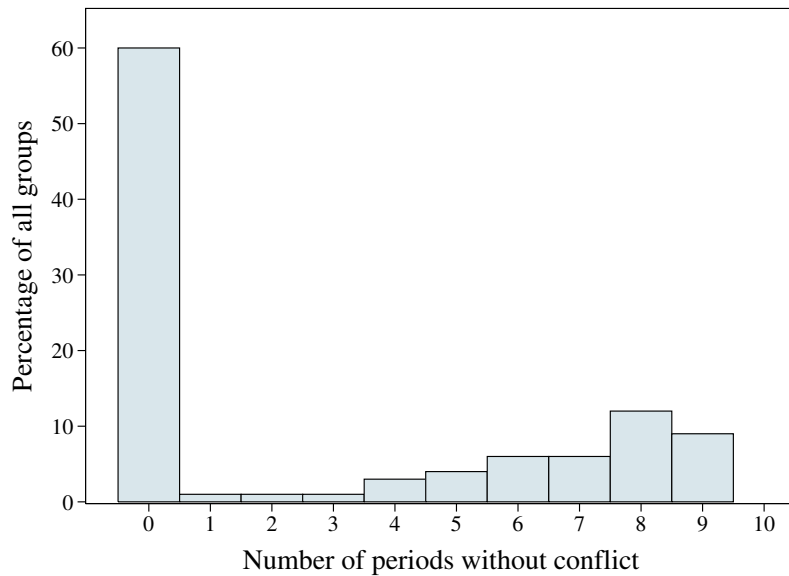


Figure 4: Frequency of peaceful periods by group

Note: Histogram showing the percentage of groups depending on the total number of periods without conflict. For groups that remain the same across periods.

3.4 The dynamics of peace

As was mentioned, the main difference between partners and strangers is the ability of the former to coordinate in the peaceful outcome of no conflict. In this section we analyze how partners manage to do this and the role that post-conflict behavior has in achieving peace.

If we look at what previous behavior predicts a peaceful outcome we clearly see that the best predictor of peace is that there was peace in the previous period. In 87.9% of the cases a peaceful period was preceded by another peaceful period. This hints at a high concentration of peaceful periods in a few groups. Figure 4 confirms that this is the case. There we can see that a majority of groups do not have one single instance in which there was no conflict and a smaller percentage has many periods in which they remained at peace. Thus it appears that when it comes to avoiding war groups either manage to do so or not. This can also be seen in Figures B1 to B3.

Given the binary nature of peaceful outcomes, we divide groups into two categories: successful groups, which are those who have five or more consecutive periods without conflict, and unsuccessful groups which do not. Note that successful groups account for 93.9% of all peaceful periods. The frequency of successful groups is similar across treatments: 34.2% in CS, 31.3% in SE, and 42.4% in RE (these frequencies are not significantly different $p = 0.566$). In contrast, behavior in unsuccessful groups looks much more similar to behavior in the strangers

treatment.¹⁰ To the point where it is no longer the case that partners have lower weapons expenditures and higher profits in SE and RE ($p > 0.197$ and $p > 0.553$), although it is still the case in CS ($p = 0.009$ and $p = 0.017$).

Some of the successful groups managed to start already with their peaceful relationship from period 1 (25.0% to be precise). However, the majority reach the peace outcome after a few rounds of conflict. Since, once peace is reached it is maintained until the last rounds, the important question is why do these groups manage to reach a peaceful outcome though interaction and others don't? To answer this we look at behavior in periods preceding the first peaceful period.

In *all* cases, the first peaceful period follows a period in which one of the two subjects chose not to spend money on weapons. Precisely, in 22.5% of the cases choosing not to fight lead to peace in the following period. In order to understand then what motivates subjects to chose not to spend anything in weapons we ran a series of probit regressions in which the dependent variable is an indicator variable measuring whether a subject i chose $w_i = 0$ or $w_i > 0$. As independent variables we use the same variables described in the section 3.3, and in addition we use an indicator variable which indicates whether their opponent j chose not to spend money in weapons in the previous period (Peace_n). We also include the period number since achieving peace is particularly important in earlier periods. Since we are interested in the first incidence of peace and not in end-game behavior, we utilize observations from periods in which there is conflict and are *not* preceded by a period without conflict. One regression for each treatment was run. The results are presented in Table 3. Note that the reported figures are the marginal effects of the coefficients at the mean values.

The results are relatively straightforward. As we can see the biggest effect on choosing not to fight is having observed their opponent chose not to fight in the previous period. In SE and RE winning the contest has a detrimental effect of the probability of choosing not to fight. Perhaps because they think they can keep winning and thus do not need to act peacefully. Also important is the post-conflict behavior. In CS choosing or observing a low take rate is associated with a higher probability of choosing not to fight. In SE and RE this is the case only for the loser. Thus in all treatments the winner of the contest can signal his willingness to cooperate by taking a low amount. In all treatments subjects are more likely to chose zero weapons expenditures in earlier periods.

¹⁰For unsuccessful groups, average weapons expenditures are 544 tokens in CS, 509 tokens in SE, and 439 tokens in RE. Average earnings are 455 tokens in CS, 390 tokens in SE, and 475 tokens in RE.

Table 3: Choosing not to fight

Note: Regressions with an indicator variable that equals one if subject i does *not* spend money in weapons in period t and zero otherwise as the dependent variable. We utilize observations from periods in which there is conflict and are *not* preceded by a period without conflict. We present one regression per treatment when groups remain the same across periods. In all cases weapons expenditures are normalized so that 1000 tokens equals 1. All independent variables refer to the period $t - 1$. We use the subscript m to refer to the winner of the conflict in $t - 1$ and n to denote the loser. Win_i is an indicator variable that equals one if $i = m$ and zero otherwise. Peace_n is an indicator variable that equals one if n did *not* spend money in weapons and zero otherwise. $w_m + w_n$ is the total expenditures in weapons. $w_m - w_n$ is the difference in weapons expenditures between m and n . $\text{Win}_i \times w_m - w_n$ equals $w_i - w_j$ if $i = m$ and zero otherwise. t_m is the take rate chosen by m (in SE n might destroy everything leaving m with no choice, in these cases we set t_m to zero). $\text{Win}_i \times t_m$ equals t_i if $i = m$ and zero otherwise. d_n is the destruction rate chosen by n . t is the period number. Probit regressions with subject random effects. The table reports the marginal effects of the coefficients at the mean values. Standard errors are in parentheses. The symbols *, **, *** indicate statistical significance at the 10%, 5%, and 1% level.

	<i>Partners</i>		
	CS	SE	RE
Win_i	-0.02 (0.02)	-0.12*** (0.05)	-0.23** (0.11)
Peace_n	0.29*** (0.11)	0.49*** (0.14)	0.34*** (0.11)
$w_m + w_n$	0.04 (0.03)	0.01 (0.03)	-0.03 (0.06)
$w_m - w_n$	-0.04 (0.04)	-0.06 (0.04)	0.17** (0.08)
$\text{Win}_i \times w_m - w_n$			-0.19* (0.11)
t_m	-0.11*** (0.04)	-0.10** (0.05)	-0.26** (0.12)
$\text{Win}_i \times t_m$		0.09* (0.05)	0.29** (0.15)
d_n		-0.04 (0.04)	0.03 (0.05)
t	-0.01** (0.00)	-0.01* (0.00)	-0.03*** (0.01)
Prediction at \bar{x}	0.051	0.041	0.085
Wald χ^2	47.73***	84.00***	83.42***
# Obs	466	404	386

4 Conclusions

In this paper we study three variations of the conflict models of Hirshleifer (1991) and Skaperdas (1992). We concentrate on how different forms of post-conflict behavior affect the decision to

allocate resources between productive and fighting efforts.

We find that, if given the choice to destroy some of their resources, many defeated players prefer to do so rather than let the winner take any of it. Given this behavior, incentives to invest in weapons as opposed to production change and lower levels of conflict are achieved. However, due to the waste of resources in destruction this does not necessarily lead to higher earnings. The most peaceful setting occurs in the Resistance game in which losers can condition their destruction on the take rate of the winners. Since winners take this into account the winners ability to take is limited by the threat of destruction and thus less resources are wasted. A lower profitability from winning translates into less resources spent in weapons.

Furthermore, we also find that in settings with repeated interaction, the subject's choice of weapons expenditures and their post-conflict behavior can serve as a form of costly communication which enables players to avoid future conflict.

We should note that it is still a puzzle why subjects invest amounts in weapons well over what the selfish Nash equilibrium predicts. This additional aggressiveness contrasts with the usual finding from many experiments that subjects are "nicer" or "fairness-oriented" than traditional economic theory would suggest.

A Supplementary Material

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 scheme sequences. Subjects played repeatedly for 20 periods. Periods 1 to 10 under the first matching scheme and periods 11 to 20 under the second one. In each periods subjects received 1000 tokens as their endowment. At the end of the experiment two periods (one for each matching scheme) were randomly selected for payment. Average earnings, including a 2.50 euro showup fee, were 16.69 euros (1000 tokens equaled 10 euros).

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

Table A1: Experimental treatments

<i>Treatment</i>	<i>Sequence</i>	
	Partners - Strangers	Strangers - Partners
Complete surrender	38 subjects	38 subjects
Resistance	32 subjects	34 subjects
Scorched Earth	32 subjects	32 subjects

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 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, in periods 1, 10, and 20 subjects were asked to self-report their experienced emotions at the end of the game.

Below is a sample of the instructions used in the experiment. It corresponds to the Resistance treatment and the strangers matching scheme. Instructions for other treatments and for partners 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 your 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].

B Additional Figures

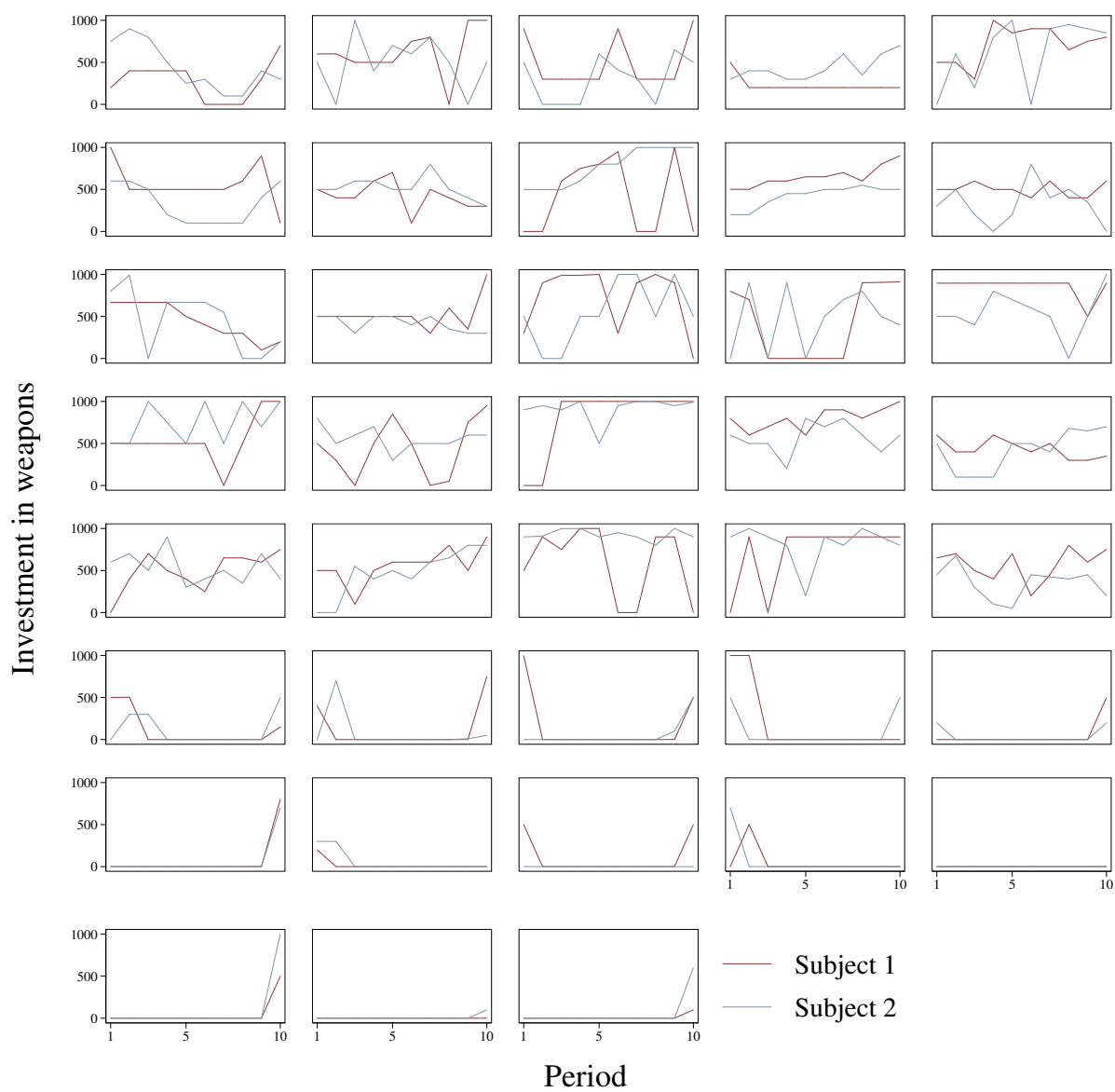


Figure B1: Weapons expenditures per group in CS

Note: Each graph shows, for the Complete Surrender treatment, the amount spent on weapons by each subject in the group. For groups that remain the same across periods. Groups classified as successful correspond to the last thirteen groups.

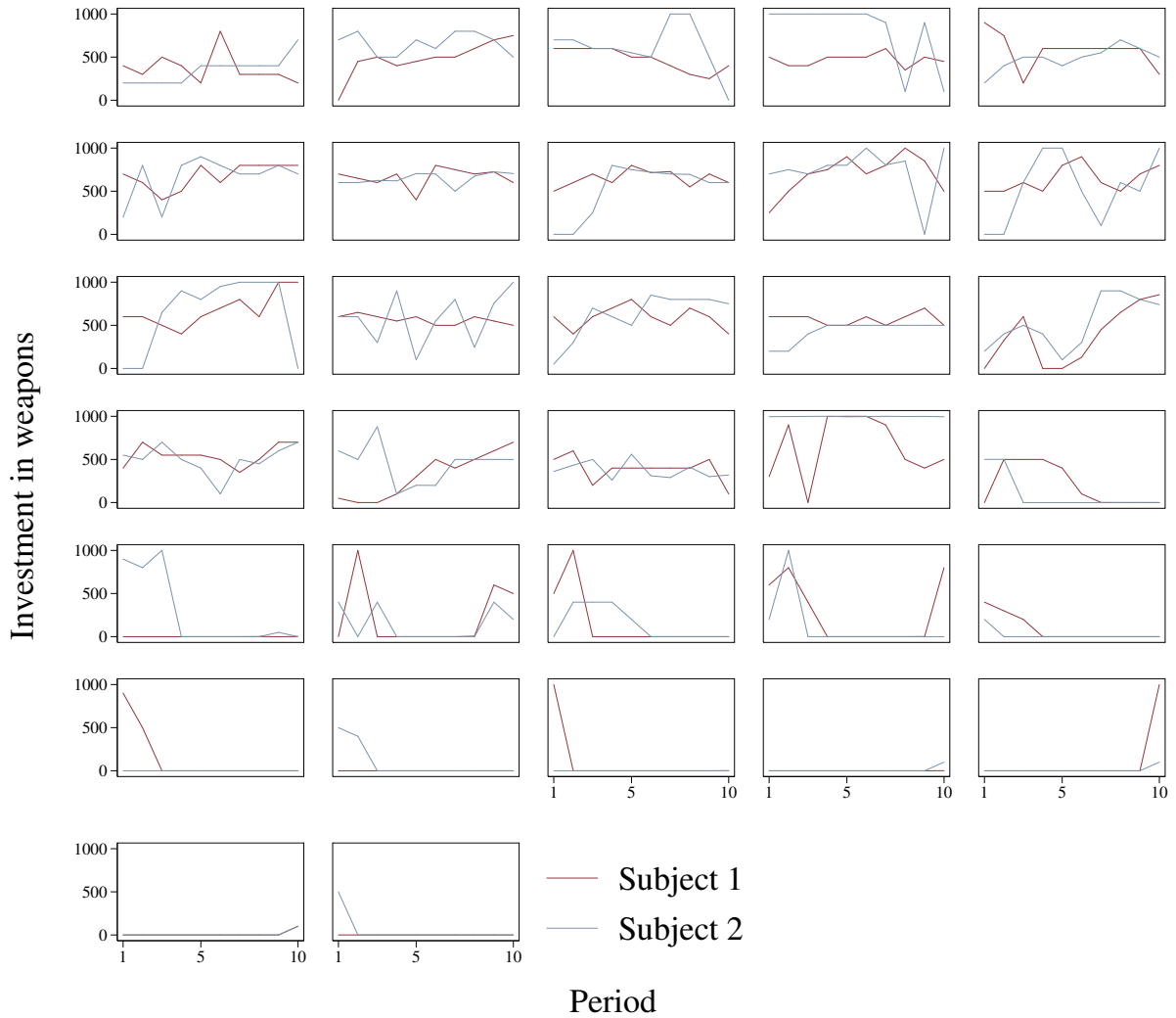


Figure B2: Weapons expenditures per group in SE

Note: Each graph shows, for the Scorched Earth treatment, the amount spent on weapons by each subject in the group. For groups that remain the same across periods. Groups classified as successful correspond to the last ten groups.

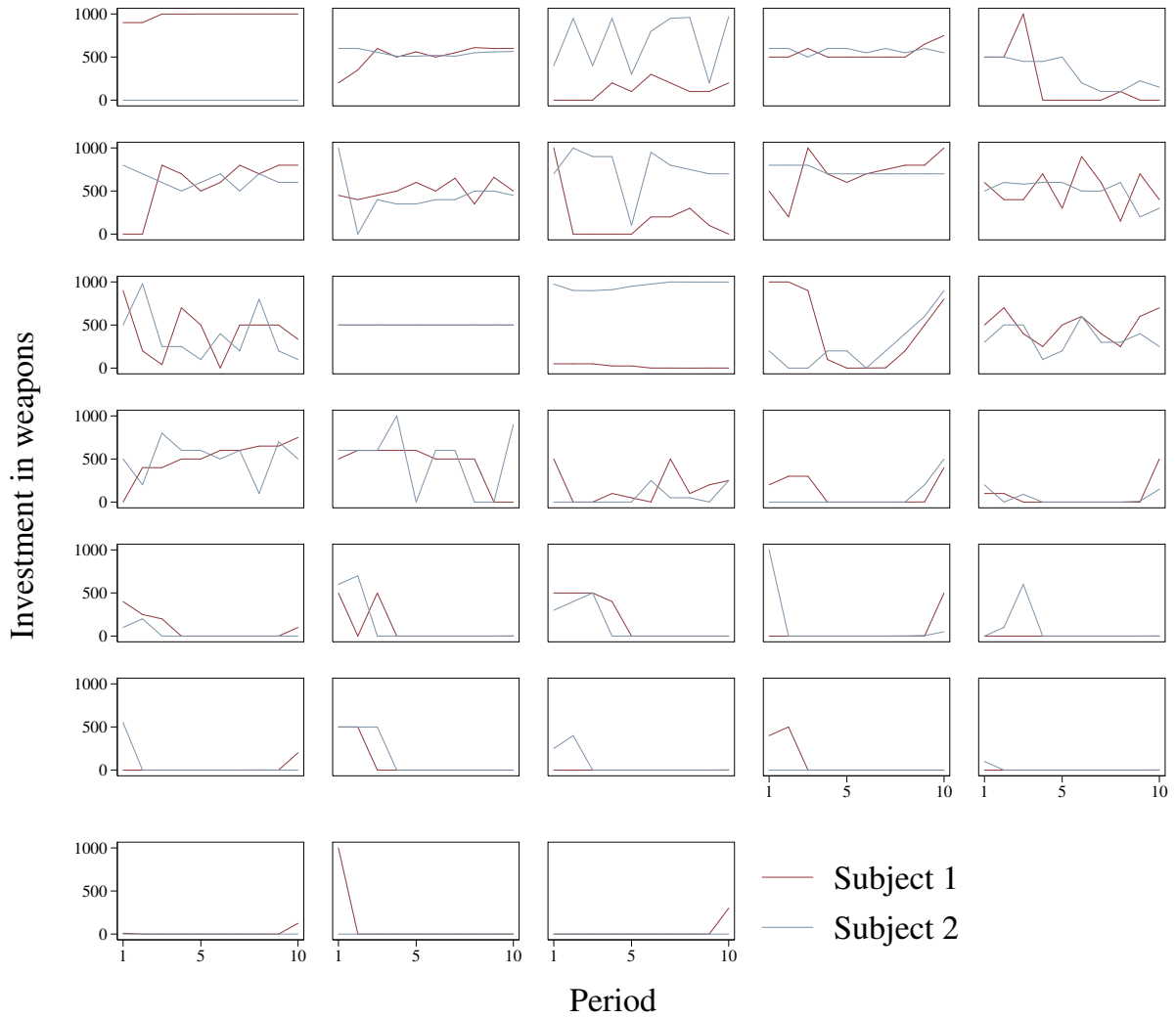


Figure B3: Weapons expenditures per group in RE

Note: Each graph shows, for the Resistance treatment, the amount spent on weapons by each subject in the group. For groups that remain the same across periods. Groups classified as successful correspond to the last fourteen groups.

C References

Bosman, R., Sutter, M., van Winden, F. (2005), On the impact of real effort and emotions in power-to-take experiments, *Journal of Economic Psychology* 26:407-429.

Benjamini, Y., Hochberg, Y. (1995), Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing, *Journal of the Royal Statistical Society Series B (Methodological)* 57:289-300.

Carter, J.R., Anderton, C.H. (2001), An experimental test of a predator-prey model of appropriation, *Journal of Economic Behavior & Organization* 45:83-97.

Durham, Y., Hirshleifer, J., Smith, V.L. (1998), Do the rich get richer and the poor poorer? Experimental tests of a model of power, *American Economic Review* 88:970-983.

Duffy, J., Kim, M. (2005), Anarchy in the laboratory (and the role of the state), *Journal of Economic Behavior & Organization* 56, 297–329.

Fischbacher, U. (2007), z-tree: Zurich toolbox for ready-made economic experiments, *Experimental Economics*, 10:171-178.

Forsythe, R., Horowitz, J.L., Savin, N. E., Sefton, M. (1994), Fairness in simple bargaining experiments, *Games and Economic Behavior* 6:347-369.

Garfinkel, M.R. (1990), Arming as a strategic investment in a cooperative equilibrium, *American Economic Review* 80:50-68.

Garfinkel, M.R., Skaperdas, S. (2006), Economics of Conflict: An Overview. *Handbook of Defense Economics*, Vol. 2 (chapter 3). T. Sandler and K. Hartley (eds.)

Gehrig, T., Guth, W., Levati, V., Levinsky, R., Ockenfels, A., Uske, T., Weiland, T. (2007), Buying a pig in a poke: An experimental study of unconditional veto power, *Journal of Economic Psychology* 28:692-703.

Grossman, H.I. (1991), A general equilibrium model of insurrections, *American Economic Review* 81:912-921.

Grossman, H.I., Kim, M. (1996), Predation and accumulation, *Journal of Economic Growth* 1:333-351.

Haavelmo, T. (1954), *A Study in the Theory of Economic Evolution*. (North-Holland, Amsterdam).

Hirshleifer, J. (1988), The analytics of continuing conflict, *Synthese* 76:201-33.

Hirshleifer, J. (1989), Conflict and rent-seeking success functions: Ratio vs. difference models of relative success, *Public Choice* 63:101-112.

Hirshleifer, J. (1991), The paradox of power, *Economics and Politics* 3:177-200.

Ho, T-H., Camerer, C., Chong, J-K (2007), Self-tuning Experience-Weighted Attraction Learning in Games, *Journal of Economic Theory* 133:177-198.

Hoffman, E., McCabe, K., Shachat, K., and Smith, V. (1994). Preferences, property rights, and anonymity in bargaining games, *Games and Economic Behavior* 7:346-380.

Neary, H.M. (1996), To Fight or Not to Fight: Equilibrium Structure in a Conflict Model when Conflict is Costly, discussion paper.

Skaperdas, S. (1991), Conflict and attitudes toward risk, *American Economic Review* 81:160-64.

Skaperdas, S. (1992), Cooperation, conflict, and power in the absence of property rights, *American Economic Review* 82:720-739.

Skaperdas, S. (1996), Contest success functions, *Economic Theory* 7:283-90.

Skaperdas, S. and C. Syropoulos (1996), Can the shadow of the future harm cooperation?, *Journal of Economic Behavior & Organization* 29:355-72.

Tullock, G. (1980), Efficient rent seeking, in: J.M. Buchanan, R.D. Tollison, and G. Tullock, eds., *Toward a Theory of the Rent Seeking Society* (Texas A&M University Press, College Station, TX) 3-15.