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***Corresponding Author's Address:** Tel.: +352 46 66 44 6285; Fax : 352 46 66 44 6835.
Tibor.neugeubauer@uni.lu

Who makes the pie bigger?
An experimental study on co-opetition

Juan A. Lacomba*, Francisco Lagos* and Tibor Neugebauer**[1]

* University of Granada, Department of Economics

** University of Luxembourg, Luxembourg School of Finance

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Abstract

The tension between cooperation and competition that characterizes many business relationships is experimentally studied in a "pie"-creation game; value is created and increased through cooperation in a repeated prisoner's dilemma game. At the end, the player with the greater stake in the joint pie decides on the division of the pie. Three treatments of the pie-creation game are considered: in the first treatment, rivals create the pie; in the second, non-rivals create the pie; finally, in the third, the pie is created by subjects who do not know about the future pie-division. The data show that the competition for the right to split the pie biases behaviors towards defection when subjects play with their rival.

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"Business is cooperation when it comes to creating a pie and competition when it comes to dividing it up" Brandenburger and Nalebuff, 1996.

1. Introduction

Business is traditionally viewed as a win-lose game where all players are competitors. However, business seems to be more complex than this victors-vanquished view of the world would suggest. Entrepreneurs must engage in joint ventures, create teams, establish strategic partnerships-eventually even with competitors-to raise the long-term value of the firm. Business can yield a win-win outcome when firms cooperate. For instance, airlines companies cooperate in sharing the airport construction costs; phone companies share the costs of establishing a (wireless or optical fiber) network; or firms form a consortium in the acquisition of another company. Rather than drawing a clear division line between friend and foe, business strategy combines both competition and cooperation. This integrated approach to business strategy is known as *co-opetition*, which can be understood as those circumstances where two (or multiple) agents simultaneously cooperate to make the pie bigger and compete with each other to get a bigger share of the pie.[2] This relationship may consist of one-shot or repeated interactions (Brandenburger and Nalebuff, 1996; Lado et al., 1997; Zerbini and Castaldo, 2007).

The game of co-opetition is complicated as frequently the short-term perspective of a consortium is at conflict with its long-term perspective. Cost sharers or cooperators in creating a market today frequently must compete for the market share tomorrow. Therefore, firms may find it more comfortable to cooperate with another firm when the other one competes in a different market or at least, from the standpoint of today, it is unforeseeable that the other one is the future competitor.[3] Hence, the game of co-opetition can be played with rivals as well as with non-rivals. Actually, the long-term short-term trade-off is not only relevant for between-firms interaction, but is also wide-spread within many hierarchical organizations in which collaborators who cooperate

[2] Related literature considers that this term comes originally from Raymond Noorda in 1993 (e.g. Gee, 2000; Ketchen et al., 2004; Walley, 2007).

[3] For instance, national railway companies of neighbouring countries cooperate in the construction of international railways to compete for customers and freight transportation with other carriers; chip-manufacturer and software producer cooperate in advanced technology development.

today in a team within an organization frequently compete tomorrow in the promotion for a higher position. Competition in such organizations, however, is manifold and the competitive pressures with respect to other organizations and the direction by the boss may dominate the competitive pressures within the peer group. To lower the competitive pressure and to foster cooperation within an organization, competition for promotion can frequently be transferred to an external institution, e.g., such as a job-market. Collaborators of today mutually benefit from the cooperation with their peers to enhance their opportunities tomorrow when they compete with others different from their peers.[4]

To capture the tension between cooperation and competition that may characterize many business relationships, we model the game of co-opetition as a two-stage game, including a pie-creation stage and a future pie-division stage. The pie-creation stage involves a repeated prisoner's dilemma game of ambiguous time horizon; the pie-division stage is a dictator game. The two stages are linked by the fact that a pie is created and made bigger through cooperation in the first stage and the shares of the pie are allocated in the second stage by the most successful player in the prisoner's dilemma game. The prisoner's dilemma game represents situations where the trade-off between competition and cooperation are present since individuals may be partly motivated to cooperate to increase the total payoff and partly motivated to compete to receive a greater share of the total payoff. Our experimental conditions make this trade-off more salient by including the future pie-division stage in which the total of the joint payoff is divided by the player with the greater stake in this total.

We have conducted three experimental treatments to examine how the shadow of future competition affects the cooperation of anonymous subjects (see section 2). In the first (*rival)* treatment, individuals face their partner of the pie-creation game in the pie-division game again. The individuals who earned relatively more, that is the one who defects more frequently than the partner, is assigned the dictator role in the pie-division game. This treatment stresses the competition aspect in the repeated prisoner's dilemma by making decisive the relative performance criterion. In the second (*non-rival)* treatment individuals play the pie-creation game and the pie-division game with different subjects. The pie in the pie-division game is the total of the cumulative payoffs

[4] Job-markets in universities frequently allow only external candidates to fill their advertised positions, and successful team-players may have comparative advantages over non-team-players.

of the two players in their repeated prisoner's dilemma games. Again, the individual with the greater stake in this total is assigned the dictator-role in the pie-division game. Hence, the dictator is likely the one whose partner in the pie-creation game cooperated more frequently. This treatment, therefore, stresses the need for cooperation of the players in the prisoner's dilemma game. Finally, in the third (*control)* treatment subjects are uninformed about the future competition.

Looking at our treatments from a theoretical perspective, under the assumption of rationality including that the dictator takes it all, the unique Nash equilibrium for the pie-creation game is mutual defection and never cooperate (see section 3). If some irrationality of the other players is believed, as in Kreps et al. (1982),[5] however, cooperation in the finitely repeated prisoner's dilemma can be consistent with rational behavior. This theoretical result is experimentally corroborated by Andreoni and Miller (1993). They consider a series of finitely repeated prisoner's dilemma games in which they manipulate subjects' beliefs about their opponent's behavior and find a consistent pattern of cooperation.

The present study shares some similarities to that of Andreoni and Miller (1993). In our case, by changing the future rival in the pie-division game we may manipulate the beliefs about the opponent's behavior in the prisoner's dilemma game. Two driving forces might affect the behavioral pattern in our prisoner's dilemma game: i) to cooperate to create a bigger pie; and ii) to compete for the future split of the pie. Since in the *rival* treatment players compete for the future split of the pie with each other, the shadow of the future may lead players to believe that their partners may behave very competitively. However, in the *non-rival* treatment players may believe that their partner is prone to cooperating in order to increase the probability of being the dictator in the future pie-division game.

In this paper, our data analysis (see section 4) is focused on the cooperation behavior in the pie-creation game. Our data show that cooperation levels in the *rival* treatment are significantly lower than in the *control* treatment. This result suggests that the competition for the future split of the pie biased behavior towards defection. On the other hand, cooperation levels in the *non-rival* treatment were higher than in the *rival* one, similar to those of the *control* treatment. This result suggests that, on average,

[5] Similar approaches have been followed in Palfrey and Rosenthal (1988) and Samuelson (1988) to provide a rationale for cooperation in the finitely repeated prisoner's dilemma game.

partners did not try to help each other to increase the probability of being the dictator in the future stage.

2. Experimental design and procedures.

2.1 Procedure

We conducted computer-driven experiments at the Leibniz University of Hannover, Germany and at the University of Granada. Subjects, arrived at the computer room, drew covered seat-numbers from a tray and went to the indicated cubicles. Written instructions (see appendix) were read aloud by the experimenter before subjects were introduced to the simple user-interface of the z-Tree program (Fischbacher, 2007).

2.2 The prisoner's dilemma stage

Subjects interacted in the repeated prisoner's dilemma game with an unknown number of repetitions in a partner's setting (Loos and Neugebauer 2007); at the beginning of the experiment they were randomly matched in anonymous pairs in which they interacted for the entire prisoner's dilemma game.[6] Subjects knew that the game-length was prefixed between ten and twenty repetitions but they do not know the actual number of periods. However, the actual number of repetitions to be played for real, which was T = 12, was not revealed to them.[7]

Before the experiment, subjects ran some interactive trials with their partner aimed at reducing initial noise and confusion (three trials in Germany and four in Spain) without any money at stake.[8] After each repetition, subjects received feedback information about their payoff and their partner's action. The screen showed the payoff

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[6] We chose the ambiguously repeated prisoner's dilemma game setting to have the same number of periods in each session and because it is a good presentation of the real world. Natural people and corporations usually do not know when a relationship ends and they do not assign probabilities to such events, if at all they rather assign maximum time length to such relationships.

[7] Several articles have analyzed the effect of infinite and finite horizon on cooperation in prisoner's dilemma games (see among others Selten and Stoecker 1986; Cooper et al 1996; Dal Bó, 2005; Normann and Wallace, 2005; Bruttel et al., 2007).

[8] The trials aimed at reducing initial noise and confusion which has been reported in other laboratory studies (Andreoni 1995).

matrix represented in Table 1; the actions defect and cooperate were represented by *A* and *B* on the subject's screen.

Table 1. Payoffs (in Euro) in the prisoner's dilemma stage game

		Player 2: Defect	Player 2: Cooperate
Player 1	Defect	0.50, 0.50	1.50, 0.00
	Cooperate	0.00, 1.50	1.00, 1.00

2.3 Treatments

After having played the ambiguously repeated prisoner's dilemma, each subject pooled her cumulative payoffs with another subject from the same room to play the dictator game over the total payoff. The one who had earned the higher payoff in the ambiguously repeated prisoner's dilemma, and thus had a higher stake in this total, was assigned the role of dictator. The dictator chose the final allocation of the total payoffs of both players. If both players had obtained the same payoffs in the prisoner's dilemma stage, then the dictator role was randomly assigned, each subject having the same probability.

Three treatments were considered; they differed with regard to the pie-sharing counterparty and the amount of information subjects received before the first-stage game:

1. Rival treatment: at the beginning of the experiment, subjects were informed that if they earned a higher payoff than their partner in the prisoner's dilemma they would be assigned the dictator-role in the pie-division decision.
2. Non-rival treatment: at the beginning of the experiment, subjects were informed that their cumulative payoffs in the prisoner's dilemma game would be pooled with the cumulative payoffs of someone else with whom they had not interacted before. The one who earned a higher payoff in the prisoner's dilemma would be assigned the dictator-role in the pie-division decision.
3. Control treatment: at the beginning of the experiment, subjects were told that they were going to receive further instructions after the prisoner's dilemma. They learned about the pie-division game only afterwards. As in the rival treatment, they played the pie-division game with their partner. A priori, however, the pie-division game could not be anticipated.

3. Theoretical considerations

In this paper, we study whether the competition for the right to divide the pie may influence the behavior in the ambiguously repeated prisoner's dilemma game. Therefore, we consider only the decisions in the prisoner's dilemma where the pie is created and neglect the decisions of the dictator game where it is divided. In our theoretical discussion, we assume that the dictator wins the whole pie. The choices of the dictatorial pie-sharing game are reported elsewhere (Lacomba et al. 2010).[9]

In the finitely repeated prisoner's dilemma, it is well known that defection in every game is the unique Nash equilibrium. This follows from the familiar backward-induction arguments. Since this behavior is common knowledge, the standard backward induction algorithm implies mutual defection in each repetition as the unique equilibrium in each of the three treatments. This result is captured in our benchmark hypothesis.

Hypothesis 1: Subjects always play defection disregarding the treatment.

However, as aforementioned, Kreps et al. (1982) show that if there is incomplete information about the types of players then cooperation early in the game can be consistent with rational behavior. Andreoni and Miller (1993) show experimentally that subjects cooperate in prisoners' dilemma games, showing an interest in increasing the general pie-size.

If both players believe that there is a small chance that their opponent may behave cooperatively, then it is in each player's best interest to build a reputation for cooperation. These beliefs may be affected by the different features of the future dictator game stage.

In the *rival* treatment, the relative payoff comparison is salient since the better performing player of the two partners determines the final allocation of the earnings. In that treatment, subjects are not only concerned with obtaining the maximum payoff

[9] However, a few observations regarding the pie-division game follow. Half of the dictators took 90% or more of the total, and 37% took it all. The average demand by the dictators were as follows; 79% in the control treatment (74% Germany, 83% Spain), 87% in the rival treatment (83% Germany, 92% Spain), and 83% in the non-rival treatment (80% Germany, 86% Spain) and overall. The differences in claims between the rival and the control treatment are significant (p=0.031), as the two-tailed Wilcoxon-Mann-Whitney test suggests.

during the prisoner's dilemma game but also with obtaining a larger payoff than the other player. The relative competition issue may therefore adversely affect the beliefs reducing the willingness of subjects to cooperate with each other.

If, on the other hand, subjects can help each other to become more competitive in comparison to third party competitors, the cooperation with the partner could be favourably affected. The *non-rival* treatment may increase the cooperative propensity since subjects have incentives to achieve and maintain prolonged cooperation as much as they can increase their likelihood of winning the dictator-role in the future stage.

However, given the uncertainty about the payoffs of her competitor in the future stage and the risk of a deviation from cooperation by the partner which increases the likelihood of not winning the dictator-role, there are also adverse effects to cooperation. A priori, we cannot say which one of these opposing effects is stronger, so that we cannot anticipate observing higher levels of cooperation in the *non-rival* treatment or the *control* treatment. Therefore we limit the following hypothesis to the comparison of the *rival* treatment with the other two treatments.

Hypothesis 2: The cooperation levels in the rival treatment are lower than in the non-rival and the control treatment.

4. Experimental results

In total 132 individuals participated in the experiment; 72 in Granada (Spain) and 62 in Hannover (Germany). In Granada, we generated 12 independent observations in each treatment. In Hannover, we generated 12 independent observations of the *control* treatment, 10 of the *rival* treatment and 9 in the *non-rival* treatment. By participating to the experiment a subject earned an average of 7.30 Euro in Granada and 8.80 Euro in Germany plus a show-up fee of 3 Euro.

The following data analysis is based on the ten paying periods for which subjects were sure to interact with another. Table 2 and Figure 1 describe the level of cooperation, i.e., the relative frequency of choosing the cooperative action. Figure 1 plots the cooperation levels over time, the trial periods inclusive. The cooperation levels indicate that subjects did play both actions Cooperate and Defect in all treatments. This finding is at odds with hypothesis 1 which suggested no cooperation in any treatment. Comparing the outcomes of the three treatments, we obtain the following result.

Result: Cooperation levels in the *control* and the *non-rival* treatment are higher than in the *rival* treatment. This evidence supports hypothesis 2 and rejects hypothesis 1.

> *Support*: Table 2 shows that cooperation levels in the *rival* treatment are lower than those in the *non-rival* treatment and even lower in comparison to the *control* treatment. The one-tailed Mann-Whitney test shows that the differences are significant; the likelihood that the observed differences (or extremer ones) between the *rival* treatment and the *non-rival* [*control*] treatment are due to chance is .000 [.047] on the total sample; .068 [.007] for the German subsample and .179 [.004] for the Spanish subsample. The differences between the *control* treatment and the *non-rival* treatment are not significant; the two-tailed Mann-Whitney test returns a p-value of .225 on the total sample, and .383 for the German and .264 for the Spanish subsample.

The results show that cooperation in the *rival* treatment is much more difficult to obtain than in the other two treatments. To exclude the possibility of confusion as a potential source for the differences, we observe that behavior is the same across treatments in the trial rounds. The two-tailed Mann-Whitney test suggests that the cooperation levels in the trial rounds are not significantly different between treatments; on the total sample which includes the subsamples from Spain and Germany the p-values are greater than .200. Although the differences may not be different on a two-sample test basis, a glance at Figure 1 reveals that the realized cooperation level of the *rival* treatment was higher than the other treatments in the trial periods but lower in the paying periods for both countries. Subjects of the *rival* treatment signal their willingness to cooperate in the trial periods, but in sharp contrast to the other treatments, this signal is no mirror of intentions. In the last trial period the relative frequency of mutual cooperation is .682 in the *rival* treatment, comparing to .375 and .429 in the *control* treatment and the *non- rival* treatment. While only one of these groups (i.e., one out of fifteen or 6.7%) continues with mutual play of cooperate in the first period of the *rival* treatment, two out of each three groups continue mutual play of cooperate in the other treatments. Therefore, we are drawn to conclude that subjects in the *rival* treatment intentionally misguided their partner subjects in order to achieve a comparative advantage.

Table 2. Average cooperation rate

	Treatment		
	Control	*Rival*	*non-rival*
Total Sample	0.479	0.170	0.381
Germany	0.625	0.285	0.511
Spain	0.333	0.075	0.283

As Figure 1 indicates and as the statistical analysis reveals, the cooperation level is trend-free in the paying periods of the *control* treatment and declining in the other two treatments.[10] The results are the same for the total sample and for the both subsamples Spain and Germany. The dynamics seem to be country independent, although contribution levels are absolutely higher in Germany than in Spain.[11]

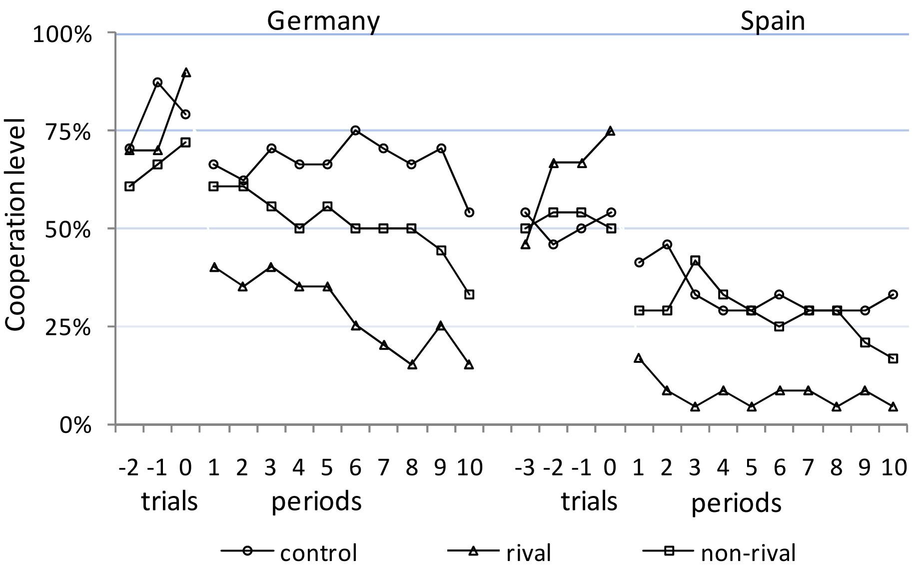

Figure 1. Cooperation levels in experiment

An additional measure of the role of the future competition across treatments is the number of subjects who either always defect or always cooperate in the repeated prisoner's dilemma game. These relative numbers have been reported in Table 3. While

[10] The random-effects logit regression of the relative choice of cooperate in a group per period {0, .5, 1} indicates that the decrease of cooperation levels is significant in the *rival* [*non-rival*] treatment; the p-value of the declining trend is .001 [.004]. The corresponding p-value for the *control* treatment is .269.

[11] The random-effects logit regression involving country dummies on trend and intercept suggests no significant differences in the trend but all treatment dummies are significant on the intercept; the corresponding p-values are greater than 0.200 and smaller than 0.100, respectively. The one-tailed Mann-Whitney test results show that the differences are significant for each treatment; the p-values are .016, .015, and .021 for the *control*, the *rival* and the *non- rival* treatments.

almost half of subjects in the *rival* treatment always play defect, only 14% and 26% play in this way in the *control* and the *non-rival* treatment respectively. Analogously, the purely cooperative behavior is almost completely removed in the *rival* treatment (only 4% of subjects cooperate always) compared with the other two treatments (25% and 19% in the *control* and the *non-rival* treatment respectively).

Across all treatments, we observe cooperation is reciprocal. If cooperation is not reciprocated, no subject cooperates always; long lasting cooperation requires reciprocity. Hence, the relative number of subjects who cooperate always as recorded in Table 3 corresponds to mutually cooperative groups.

Table 3. Behavioral pattern

		Treatment		
		control	*rival*	*non-rival*
Average	cooperate always	0.250	0.045	0.191
	defect always	0.142	0.477	0.262
Germany	cooperate always	.333	.100	.222
	defect always	.000	.300	.056
Spain	cooperate always	.167	.000	.167
	defect always	.283	.625	.417

5. Conclusions

The aim of this paper has been to provide some experimental evidence on one particular aspect of co-opetition; what impact has an anticipated future competition of slicing the pie on the current cooperative behavior of increasing the pie? For this purpose, we conducted experiments in which non-rivals or rivals of tomorrow can cooperate today. A main result has emerged from our data analysis. High cooperation levels between partners are more easily achieved if partners are no future competitors or even better if they do not anticipate their future competition. According to our results, non-competitors make thus the pie bigger than competitors.

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7. Appendix.

Instructions (translated from German and Spanish)

Welcome to the experiment. Please switch of your mobile telephone now. Follow the instructions carefully and please indicate by raising your hand if you do not fully understand them. During the entire experiment, please do not contact any other participant. If you do so, you will be asked to leave the experiment and you lose all rights for payment. The experiment aims at understanding individual decision making; hence, it is necessary that you make your decisions on your own.

In the experiment you are going to interact repeatedly with the same participant whose identity is determined at the beginning of the experiment but which will not be revealed to you at any time.

With the determined participant, you will play at least for 10 rounds and at most for 20 rounds for real money; the exact number of rounds is not revealed to you in advance.

Before you start the experiment, you play three trials with the other participant without receiving any payment.

In each round, you decide to take one of the two actions A or B and confirm your choice through the press on the button on the computer screen.

Depending on the actions you and the other participant choose, the round payoffs result according to the following table.

Payoff table. (your payoff; payoff of the other)

		The other's action			
		A		B	
Your action	A	0,50	0,50	1,50	0,00
	B	0,00	1,50	1,00	1,00

<u>How you read the table:</u>

If both choose action A, each of you wins €0.50. If you choose action A and the other chooses action B, you win €1.50 and the other wins nothing. If you choose action B and the other chooses action A, you win nothing and the other wins €1.50. If both choose action A, each of you wins €1.50.

After each round you will be informed about the decision of the other participant and the resulting payoffs. The total payoff in the experiment corresponds to the sum of your round payoffs.

(The following instructions differed with respect to the treatment):

Subjects in the *control treatment* read: At the end of the experiment you are going to receive further instructions.

Subjects in the *rival treatment* read: At the end of the experiment your total payoff will be added to the total payoff of participant with whom you have interacted to determine the joint payoff. Whichever of the two of you getting higher cumulative payoffs decides how to divide up this joint payoff. Thereafter, you will discreetly receive your payoff paid out in the institute by our secretary in private.

Subjects in the *non-rival treatment* read: At the end the experiment you will be randomly matched with another, unknown participant from the room with whom you have not interacted in the experiment. Your total payoff will be added to the total payoff of this other unknown participant to determine the joint payoff. Whichever of the two of you getting higher cumulative payoffs decides how to divide up this joint payoff. Thereafter, you will discreetly receive your payoff paid out in the institute by our secretary in private.