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Free-Riding et bienveillance dans la relation principal – multi-agents : Evidence expérimentale

CLAUDE MEIDINGER*, JEAN-LOUIS RULLIERE** AND MARIE-CLAIRE VILLEVAL**

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Abstract: How do intrinsic motivations such as fairness and reciprocity influence the efficiency of a principal – multi-agent relationship when joint production in a team is considered? Focusing on moral hazard in teams (Holmström, 1982), this paper reports the results of an experiment designed to determine whether principal's fairness helps in reducing free-riding amongst team members. Two treatments were run, with reshuffling (stranger treatment) and without reshuffling (partner treatment). Experimental evidence shows that i) offers of fair contracts favor team cooperation in the stranger treatment, whereas ii) repeated interactions do not necessarily improve team cooperation. All the results of the partner treatment point to the difficulty of establishing a fruitful cooperation between principals and team members unequally motivated by genuine fairness considerations.

Keywords: Fairness, Experimental Economics, Principal-Agent Relationship, Team Production.

JEL Classification: J33, C91, C92, D63

Résumé: Comment les motivations intrinsèques telles que la bienveillance et la réciprocité influencent-elles l'efficience de la relation principal - multi-agents dans le travail en équipe? Cet article rapporte les résultats d'une expérience conçue pour déterminer si la bienveillance du principal vis-à-vis des agents permet de limiter le free-riding parmi les membres d'une équipe. Deux traitements ont été réalisés, l'un avec recomposition des appariements à chaque répétition (traitement de type « stranger ») et l'autre avec groupes fixes (traitement de type «partner »). Les résultats expérimentaux montrent que i) les offres de contrats équitables favorisent la coopération au sein de l'équipe dans le traitement « stranger », tandis que ii) les interactions répétées n'améliorent pas nécessairement la coopération en équipe. Tous les résultats du traitement «partner » montrent la difficulté à établir une coopération fructueuse entre le principal et les membres d'une équipe motivés à des degrés différents par des considérations de bienveillance.

Mots clés: équité, économie expérimentale, relation principal-agent, production en équipe.

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1. INTRODUCTION

What is the impact of intrinsic motivations such as fairness and reciprocity on the efficiency of the principal – multi-agent relationship ? The importance of vertical fairness in the interactions between a principal and an agent has been documented by many experimental studies; the principal pays higher wages than those required by the incentive constraint and the agent delivers a level of effort greater than the one theoretically predicted (Anderhub, Gächter, and Königstein, 1999; Fehr, Gächter and Kirchsteiger, 1997; Fehr, Kirchsteiger, and Riedl, 1998; Güth, Klose, Königstein and Schwalbach, 1998; Keser and Willinger, 2000).

These experimental results have been obtained in designing principal – agent games as a one-to-one relationship in which one principal faces one agent. However, in real life, most people are working within teams. Do these results hold when considering a principal – multi-agent relationship? As pointed out by Holmström in his seminal paper on moral hazard in teams (1982), a multi-agent setting is characterized both by an incentive for agents to free-ride in the context of joint production and by competition in controlling incentives, as agents play a non-cooperative game. An optimal allocation cannot be achieved as a Nash equilibrium with a binding budget balancing constraint (where the outcome is fully allocated to team members). A budget breaking rule, realized by introducing a principal as a residual claimant, can be efficiency-enhancing. The rule stipulates that the joint outcome will accrue to the principal in the event that the actual outcome has not reached the expected target level. Introducing a budget breaker would be more efficient than an active monitoring.

However, this punishment mechanism faces serious drawbacks. A problem of moral hazard on the part of the principal can be pointed out (Eswaran and Kotwal, 1984). With such a contractual arrangement, the third party has an incentive to bribe one team member to shirk and this clandestine deal results in a sub-optimal outcome. Rasmusen (1987) also shows that an all agent contract can still be efficient if workers are risk averse. Free-riding in a team can be eliminated by introducing a lottery in a “massacre contract” in which one randomly selected agent is rewarded and all the other agents are punished when an out-of-equilibrium outcome is achieved by the team. In contrast, Andolfatto and Nosal (1997) extend Holmström's perspective in designing a contract in which delivering a payment to the principal even though the desired outcome has been achieved helps reducing the agents' incentive to free-ride.

As far as principal-multi-agent relationships are considered, this paper intends to pursue this analysis by asking whether fairness and reciprocity help in reducing free-riding within a team. Our aim is not to design the more efficient payment scheme but to identify the influence of intrinsic motivations on the result of a principal – multi-agent relationship, beyond the respect of participation and incentive compatibility constraints. How do the proportion of the total revenue kept by the principal for himself (index of vertical fairness) and the threat of punishment (index of negative reciprocity) affect effort decisions within a team? Does vertical fairness favor solidarity amongst team members?

It should be noted that recent supporting evidence for horizontal fairness between agents has also been reported from experiments which consider either an all agent framework (Nalbantian and Schotter, 1997; Königstein and Tietz, 1998; Carpenter, 1999) or a principal – multi-agent framework (Rossi and Warglien, 1999; Güth, Königstein, Kovacs, and Zala-Mezo, 1999). In Güth and alii however, the authors do not really design a team but rather a collection of separate contracts between a unique principal and many agents. Experimental evidence of horizontal fairness is here delivered very indirectly, through the existence of less asymmetric contracts offered by the principal and through a lower dispersion of efforts when contracts are observable by all agents. Rossi and Warglien's approach is closer to ours inasmuch as it investigates how principal's fairness influences cooperation between two interdependent agents performing a production game. Our approach is however different. We consider heterogeneous agents and a threat of punishment by the principal.

Distinctively, this paper reports an experiment designed as a principal – multi-agent game in which a principal faces a team composed of two players with different productivity levels.

The principal first offers a contract that, in exchange of a non-binding desired outcome, specifies a team payment scheme (TPS-1) under which each agent receives an equal share. In such a scheme, because unequal production skills (i.e. unequal productivity) amongst agents depend on natural endowments such as talents, the principal asks each agent to provide a same effort. Despite their differences in talents, she pays them according to a scheme based on a collective ownership in talents (see Fleurbaey and Maniquet, 1999). Agents with different productivity levels but developing the same effort suggested by the principal will receive the same payoff.

The offer can be more or less generous, depending on both the share that the principal keeps for herself (either 25% or 50% of the outcome) and on the effort level suggested to achieve the desired outcome.

If the actual outcome is less than the desired one, the principal can decide whether she applies the previous TPS-1 or a second team payment scheme (TPS-2) under which wages are individualized according to productivity levels. In that case, each player bears a share of the TPS-2 implementation cost. This approach based on a private ownership of talents is substituted to the other one based on a collective ownership of talents.

With players only motivated by pecuniary incentives, it is obvious that the threat to apply TPS-2 is not credible. And because both agents develop a dominant free riding strategy under TPS-1, the outcome will be a non cooperative one. Things can nevertheless be different if players take into account fair behavior.

In real life as in many experiments, the willingness to be kind to others seems highly contingent on the behavior of others. People help those who are helping them and hurt those who are hurting them (Rabin, 1993). Clearly, such a behavior can entail some economic consequences both on vertical relationships (between the principal and the team) and on horizontal relationships (between team members). A generous contract offered by the principal in a framework of skill solidarity may, by reciprocity, induce cooperation within a team, as well as free riding in such a situation can trigger punishment. Intrinsic motivations within team (solidarity, peer pressure or mutual monitoring) may have something to do with the success of cooperation (Kandel and Lazear, 1992).

This paper reports the results of two repeated game experiments with and without reshuffling that allow to study the impact of reciprocity and reputation in principal-multi-agent sequential move games. Two series of experiments were run, a stranger treatment (with reshuffling) and a partner treatment (without reshuffling). The stranger treatment serves as a benchmark for measuring the extent of genuinely reciprocal fairness (leading to non-strategic conditional behavior to reward kind acts and to punish unkind ones even if costly). The partner treatment leaves room for reputation building.

Experimental evidence shows that, in the stranger treatment, offers of fair contracts, some of them being equity-based, induce team cooperation, whereas offers of unfair contracts always induce team defection. This result is similar to those reported by Rossi and Warglien (1999). Despite the prediction that we should observe neither principal's fairness nor team cooperation if subjects are only motivated by pecuniary considerations, team cooperation occurs in half of fair contracts. Therefore, vertical behavior influences horizontal behavior within a team. However, in opposition to many other experimental results, repeated interactions do not necessarily improve team cooperation. All the results of the partner treatment point to the difficulty to establish a fruitful cooperation between principals and team members unequally motivated by fairness considerations. In the partner treatment, vertical behavior also influences horizontal behavior, through notably the agents' interpretation of intentions.

The remainder of this article is organized as follows. Section 2 develops the model and presents the general frame of the game, the four stages of the game, the standard strategic analysis of the game and its strategic analysis when reciprocal fairness is taken into account. Section 3 gives a brief presentation of the experimental design. Section 4 analyses the experimental results. A brief conclusion is given.

2. THE PRINCIPAL – MULTI-AGENT GAME

The game involves three players, a principal (player X) and a team composed with two agents (players Y_1 and Y_2). These matched players have to share an outcome whose amount depends on their decisions.

2.1. The general frame of the game

Let us first define r_i and e_i as player Y_i's productivity and effort levels, respectively, with $i \in \{1,2\}$. The resulting outcome is then $py = p(r_1 e_1 + r_2 e_2)$, with $p = 12$, the price of the output, and $r_1 = 1$, $r_2 = 2$. That outcome has to be divided according to a sharing scheme decided by the principal and which depends on both a parameter q (that determines the principal's share) and a team payment scheme (that determines the allocation of $(1-q)py$ between the agents).

Two team payment schemes are available in the game.

- The first one, TPS-1, consists of a team payment scheme according to which each agent receives an equal share of the outcome whatever his productivity level. This solidarity scheme is based on the idea of a collective ownership in talents. The players' shares are qpy for the principal and $(1-q)py/2$ for each agent.
- The second one, TPS-2, is a productivity-based team payment scheme. This second scheme is based on the idea of a private ownership in talents. In that case, the implementation of individualization entails a cost C_0 (with C_0 =48) that is subtracted from py before the sharing. The players' shares are $q(py - C_0)$ for the principal and $(1-q)(py - C_0)\dfrac{r_i}{r_i + r_j}$ for agent i.

In both TPS-1 and TPS-2, the principal's payoff is equal to her outcome share and the agents' payoffs are determined by subtracting from their outcome shares a personal cost of effort $C(e_i) = \dfrac{e_i^2}{a}$ with $a = 4$. When running the experiments, we added 100 to these theoretical payoffs in order to avoid negative earnings.

The game therefore consists of the following elements.

The principal designs a labor contract and makes a "take it or leave it " offer to the agents. The contract specifies a desired outcome that can be realized through a common non-binding level of effort $e^* \in E = \{2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24\}$ provided by each agent. It also specifies a value for q, either equal to 0.5 or 0.25 which, once chosen, will be retained for both TPS. When the actual outcome, resulting from the agents' efforts, equals at least the desired outcome, TPS-1 is applied. When that expected outcome has not been achieved, the principal can freely decide to apply either TPS-1 or TPS-2.

In spite of the fact that e^* is not binding, that level of effort is nevertheless indicated by the principal to her agents, as a kind of cheap talk.

2.2. The four stages of the game

- In the first stage, the principal indicates to the agents a common non-binding level of effort $e^* \in E$ that determines a desired outcome amounting to $py^* = pe^*(r_1 + r_2)$ and chooses a q either equal to 0.25 or 0.5.
- In the second stage, informed about the principal's offer, each agent independently accepts or declines the offer. If at least one agent refuses the contract, the round is over and the players' payoffs are null. If both agents accept, the third stage starts up.
- In the third stage, each agent Y freely and independently chooses in E a level of effort. This determines an outcome $py = p(r_1e_1 + r_2e_2)$ to be shared.
- In the fourth stage, the principal is informed about the actual outcome py. If $py \geq py^*$, she applies TPS-1. Otherwise, she can choose between enforcing TPS-1 or applying TPS-2, keeping the same value of q in both cases.

The four stages of the game are common knowledge for all players at the start of the game. Tables 1 to 12 in Appendix show the payoffs' matrices for the two agents and the principal under TPS-1 and TPS-2.

2.3. The standard strategic analysis of the game

Because we avoid negative earnings, the participation constraint of a non-negative payoff for the agents is clearly satisfied. And if the two agents cooperate and follow the principal's suggestion, a maximum common level of $e^* = 24$ has to be required to maximize the principal's payoff. Under TPS-1, with $q = 0.25$, that level of effort will also maximize the agents' cooperation payoffs $p_i coop$, but not with $q = 0.5$. In that sense, if the principal wants the agents to cooperate, she has to take into account an incentive compatibility constraint given by:

$$e^*(q) = Arg \max_{e} p_i coop \qquad (1)$$

We therefore have $e^*(0.25) = 24$ and $e^*(0.5) = 18$.

But clearly, that will not be enough to ensure the agents' cooperation. The principal must also take into account the possibility of using TPS-2 as a credible threat.

From the agents' point of view, regardless of the TPS adopted, both of them have a dominant free riding strategy. These strategies are under TPS-1:

$$e_{ifr} = a(1-q)p\frac{r_i}{4} \qquad (2)$$

and under TPS-2:

$$e_{ifr} = a(1-q)\frac{p}{2}\frac{r_i^2}{r_i + r_j} \qquad (3)$$

In Tables 1 to 12 in Appendix, these strategies lead to the following effort values:

- With $q = 0.25$, under TPS-1: e_{1fr} =8 or 10 and $e_{2fr} = 18$
- With $q = 0.25$, under TPS-2: e_{1fr} =6 and $e_{2fr} = 24$
- With $q = 0.5$, under TPS-1: e_{1fr} =6 and $e_{2fr} = 12$
- With $q = 0.5$, under TPS-2, $e_{1fr} = 4$ and $e_{2fr} = 16$.

In one-shot games or in repeated games with reshuffling, with players only motivated by pecuniary incentives, the threat to apply TPS-2 is not credible. It follows that both agents have an incentive to free ride whatever the value of q and will play their dominant free riding strategy under TPS-1. The predicted outcome will then be a free riding solution. With $q = 0.25$, payoffs will be 282 for Y_1 and 217 or 226 for Y_2. With $q = 0.5$, payoffs will be 181 for Y_1 and 154 for Y_2. The principal's payoff p_p will be equal to 232 or 238 with $q = 0.25$ and equal to 280 with $q = 0.5$. Therefore, by backward induction, *the principal's best choice is to select $q = 0.5$ in the first stage of the game and not to apply TPS-2 after a deviation in the fourth stage.*

In repeated games without reshuffling, is there any interest for the principal to build a reputation of toughness ?

For $q = 0.25$, both agents get a payoff of 280 if they cooperate by achieving the effort level of $e^* = 24$ suggested by the principal. When TPS-2 is considered as a credible threat, an agent that defects has to play his free riding strategy under TPS-2. With such a strategy, Y_1 cannot hope to get more than a payoff of 241 when free-riding under TPS-2 and therefore has an interest to cooperate if he expects Y_2 will cooperate. But confronted with a cooperative Y_1, Y_2 has an interest to trigger TPS-2. By playing $e_2=22$, he will get a payoff of 363. Knowing that, Y_1 will not cooperate and the outcome will then be the free riding solution under TPS-2 with a principal's payoff of 250.

For $q = 0.5$, and therefore $e^* = 18$, both agents get a payoff of 181 if they achieve the required effort level. But here too, it is clear that agent Y_2 has an incentive to trigger TPS-2 if he conjectures that Y_1 cooperates. By playing his free riding strategy $e_2 = 16$ under TPS-2, he will get a payoff of 220 instead of

181. Knowing that, agent Y_1 will not cooperate and the outcome will be the free riding solution under TPS-2, $e_{1fr} = 4$ and $e_{2fr} = 16$, with payoffs of 160 for Y_1 , 164 for Y_2 and 292 for the principal.

Therefore, in a repeated game without reshuffling, *the principal's best choice is to select* $q = 0.5$ *in the first stage of the game and to apply TPS-2 after a deviation in the fourth stage.*

2.4. The introduction of fairness considerations

It is clear that some contracts can be considered as being fair. With $q = 0.25$ and $e^* = 24$ for example, the principal is going to accept a reduced payoff of 316, instead of a payoff of 424 she can expect by asking for $e^* = 18$ with $q = 0.5$. She also offers the agents the opportunity to get an increased payoff of 280 if they cooperate, to be compared to the payoff of 181 they could get with $q = 0.5$ and $e^* = 18$. It is also clear that among fair contracts ($q = 0.25$), some of them can also be considered as being equity-based. With a suggested level of effort $e \leq 18$, each employee's payoff is equal to or greater than the principal's payoff. Such a vertical fairness may induce agents to cooperate. It may also motivate the principal to apply the TPS-2 threat (negative reciprocity) in order to punish the agents for not responding positively to her kindness even in a one-shot game.

One should also note that with $q = 0.5$, because the principal's payoff is always greater than the agent's payoffs for any suggested level of effort, there can be no equity-based contracts. But there can be unfair contracts with a level of suggested effort above the one determined by the incentive compatibility constraint. For $e > 18$, the principal tries to reinforce her first mover advantage by using cheap talk to suggest a high level of effort.

From that point of view, it seems that vertical fairness may lead to a more fruitful interpretation of observed behavior.

In one-shot games or repeated games with reshuffling, because reputation is ruled out by design, any contract with $q = 0.25$ may be interpreted as a contract offered by a principal motivated by fairness considerations. A look at the principal's strategy may also allow to distinguish principals playing fair only for strategic reasons from principals genuinely motivated by fairness. Only the latter will punish agents for not responding kindly to a fair offer.

In repeated games without reshuffling, where there is scope for reputation building, two different types of principals must be distinguished.

- On the one hand, greedy principals trying to maximize their payoffs with $q = 0.5$ through a toughness reputation that destroys team cooperation. With TPS-2 credible, Y_2 will defect, the punishment will be applied and $p_p = 292$ (better than 280 obtained without punishment for $q = 0.5$).
- On the other hand, genuinely kind principals trying to enforce cooperation through fair offers with a maximum payoff of $p_p = 316$. It should be noted that vertical fairness will usually not work without something that could be related to fair behavior among team members. Without punishment, Y_1 has a strong incentive to free ride (under TPS-1, he is offered half of the team's payoff despite his lower productivity and he will get a free riding payoff greater than Y_2's payoff). With punishment, Y_2 has the same incentive. It is also worth noting here that greedy principals have interest to mimic genuinely kind principals if they consider that fairness can be an efficient means to increase their payoff.

3. EXPERIMENTAL DESIGN

The experiments were performed in November 1999 at the University of Lyon. They were run in a computerized way with Regate as experimental software. Subjects were drawn from the undergraduate population at the Management School of Lyon and no subject was experienced. Before the experiment started, written instructions were distributed to the participants and read aloud. A pre-experimental questionnaire was distributed in order to check whether the rules of the game were fully understood. The payoffs functions and the productivity distribution are common knowledge. Tables were distributed to participants indicating the principal's and each employee's payoffs according to the individual effort levels, for each sharing rule (TPS-1 and TPS-2) and each value of the q parameter (see Appendix).

12 subjects participated in a session (4 groups of 3 subjects for each period). 4 sessions were organized (3 sessions with 4 groups and 1 session with 3 groups). It gives 15 groups of observations. Each subject was randomly assigned either the role of a principal (player X), or the role of an employee with a low (player Y_1) or a high productivity (player Y_2). In each period, each principal is matched with two heterogeneous employees.

Two treatments were run.

- A first series of sessions consisted of a "stranger treatment" (7 groups). Each subject played 15 rounds of the game in the same role but he could be matched with different players all along the session. The matching of a principal with two agents was determined randomly each period. This treatment excludes repeated game effects.
- A second series of sessions consisted of a "partner treatment" (8 groups) without reshuffling. In this case, each subject played 15 rounds of the game, staying in the same role and matched with the same two other players all along the session. This treatment enables to observe reputation effects and the principal's will to build a toughness reputation.

Each session started with 5 trial periods (which the results were not taken into account for analyses and payments) in order to help players to get accustomed with the rules of the game.

In each period, employees are informed of the level of effort suggested by the principal, e^*, of the outcome share q the principal intends to keep for herself, of the amount of the actual outcome, py, and of the team payment scheme which will be actually implemented (TPS-1 or TPS-2). In each period, the principal is informed of the acceptance or rejection of the contract, and of the size of the actual outcome. Each player in each period is also informed of the payoffs received by the two other players with which he is playing. This ended the period. During the experiment, each player could see on the upper half of his or her computer screen a table showing his or her decisions and results in all previous rounds of the game.

At the end of the session, each player was paid his or her average net payoff in the 15 rounds in French Francs according to the conversion rate 1 ECU= 0,4 FF. A showing up fee of 20 FF was added.

IV – EXPERIMENTAL EVIDENCE

The total number of contracts offered by the principals is 105 in the stranger treatment (ST) and 120 in the partner treatment (PT). Let us consider successively these two treatments.

4.1. The stranger treatment

Contracts: 26 contracts (25%) are fair (q=0.25) and, among them, 18 contracts are equity-based. Out of the 79 remaining contracts with q=0.5, 33 contracts (42%) are unfair. A one-tailed binomial test leads, under the normal distribution approximation, to the rejection of the hypothesis H_0 (no difference between the probabilities of choosing $q = 0.5$ or $q = 0.25$) at a significance level of 0.005, and to the acceptance of a greater probability to choose $q = 0.5$.

Due to the binding participation constraint, all contracts offered should be accepted since they offer payoffs strictly greater than zero. All contracts offered with q=0.25 are accepted and 4 contracts with q=0.5 are rejected. This yields a total of 101 contracts accepted.

The distribution of the effort values e according to the different values of q is given in Figure 1.

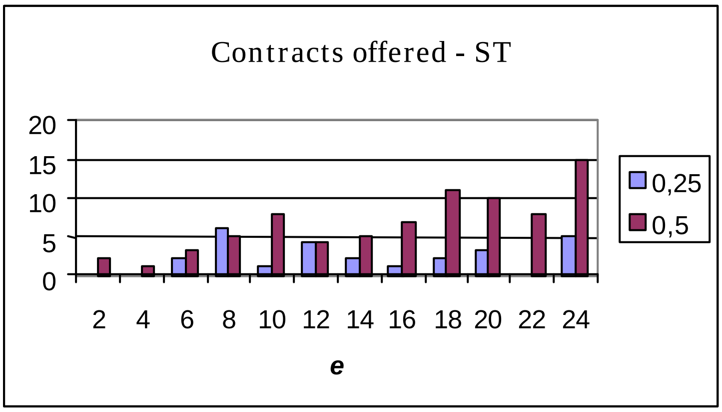

Figure 1. Distribution of offers according to the value of theta and the suggested effort level (e) in the stranger treatment

With q =0.25, *e* should be equal to 24 but in fact, only 19% of the contracts respect this incentive compatibility constraint. 81% of the contracts suggest a lower level of effort.

With q=0.5, 14% of the contracts respect the incentive compatibility constraint (*e*=18). 42% of offers suggest a level of effort higher than the incentive compatibility constraint (unfair offers).

Team cooperation: defined as the respect by both agents of the suggested effort level, it should be noted that team cooperation is weak (21% of accepted contracts) (see Table 1).

# cases	*Suggested effort (e)*												Total
	2	4	6	8	10	12	14	16	18	20	22	24	
$q = 0.25$													
Accepted contracts			2	6	1	4	2	1	2	3		5	26
Team cooperation			1	6	1	2	1	0	0	1		1	13
$q = 0.5$													
Accepted contracts	2		2	5	8	4	5	7	11	9	7	15	75
Team cooperation	2		1	2	1	0	0	1	1	0	0	0	8

Table 1. Team cooperation in the stranger treatment

Team cooperation is observed in 50% of accepted contracts with q =0.25 but only in 11% of contracts with q =0.5. Unfair contracts (q =0.5 and e>18) never induce team cooperation. By contrast, equity-based contracts (q =0.25 and $e \leq 18$) usually support team cooperation. Therefore, with a broader fairness concept including equity considerations, it seems here that principal's fairness helps in reducing free-riding within the team (positive reciprocity).

If one looks now at the individual agent behavior, one should note that the rates of defection increase with the value of *e* and are generally greater for q=0.5 than for q=0.25. When q=0.25, the less (more) productive agent defects in 38.5% (42.3%) of the contracts. When q=0.5, the less (more) productive agent defects in 73.3% (70.7%) of the contracts. For both values of q, a c^2 test (at a level of significance of 0.60) leads to the acceptation of equal frequencies of defection for agents Y_1 and Y_2 (c^2 = 0.3252 for q=0.25 and 0.2198 for q=0.5).

Punishment: in the stranger treatment, a principal motivated only by pecuniary considerations should never apply punishment (TPS-2). The experimental evidence shows that punishment has been applied in 13 cases out of 80 group defections (16.2%) and just once with q=0.25 (negative reciprocity). One should point out that punishment, applied in 6 of the unfair contracts, reinforces in those cases the principal's meanness. The evidence therefore mostly points to principals either playing fair for strategic reasons or trying to maximize their payoffs through a first mover advantage with q=0.5.

Payoffs: As displayed by Table 2, fair contracts produce more efficient results. The average size of the pie is greater for q=0.25 than for q=0.5. Equity-based contracts are not however more efficient than this average. By contrast, by suggesting high efforts, unfair contracts somehow succeed in achieving an amount to be shared greater than the average one obtained when q=0.5.

Nature of contracts	*Average size of the pie*	*Principal's payoff*	*Less productive agent's payoff*	*More productive agent's payoff*
All contracts	708.2	265.0	173.0	170.2
Contracts				

with q=0.25	824.3	230.6	242.9	228.6
Equity-based contracts	812.0	228.0	240.9	226.1
Contracts with q=0.5	670.0	276.3	149.9	151.1
Unfair contracts	713.1	296.1	159.9	150.2

Table 2. Average payoffs in the stranger treatment

Fair contracts (including equity-based ones) produce a quasi-equal pie sharing among the three players, with a small advantage to the less productive agent. As a matter of fact, the principal gets her worse payoff when she offers equity-based contracts and her best payoff when she offers unfair contracts. But for both agents, the payoff gap between these two kinds of contracts is larger by far.

4.2. The partner treatment

Contracts: 8 groups have played the partner treatment, giving 8 series of independent observations (120 contracts offered).

39 contracts (33%) are fair (q=0.25) and among them, 22 contracts are equity-based ($e \leq 18$).Only 38% of the 39 contracts respect the incentive compatibility constraint.

In the 81 remaining contracts with $q = 0.5$, only 5% respect the incentive compatibility constraint. 31 contracts (38%) are unfair ($e > 18$).

In spite of the fact that the proportion of contracts offered with q=0.25 is greater in the partner treatment (33%) than in the stranger treatment (25%), it should be noted here that a c^2 (corrected for continuity) leads to the acceptation of equal frequencies of both types of contracts in both populations ($c^2 = 1{,}58$ with a probability of 0.20). This may point to the fact that greedy principals do not really see any interest to mimic fair principals in order to build a reputation of fairness. A similar comparison made respectively for the first round of the repeated game (t=1) and the last round (t=15) shows no significant difference (at a level of 0.70) between the two populations.

However, it seems that most contracts with q=0.25 cannot be interpreted as a sign of principal's fairness. Unlike the stranger treatment, in the partner treatment one should look at the evolution of proposed contracts over time to appreciate fairness intentions.

A look at Figures 2 and 3 below shows that only three principals out of eight start the repeated game by offering fair contracts and that most of the fair contracts are proposed at rounds 10 and 11 (Figure 2), just after a sharp decline of the average size of the pie at round 9 (Figure 3).

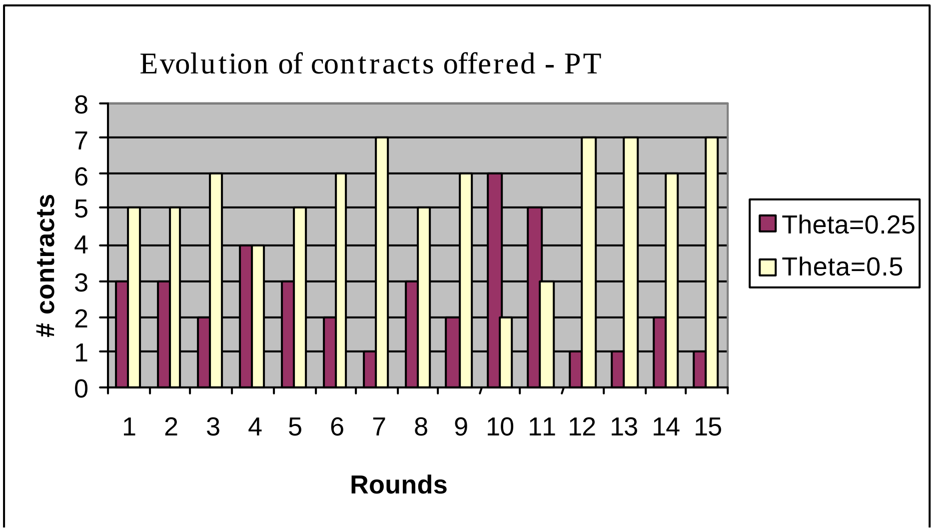

Figure 2. Evolution of the value of theta over time in the partner treatment

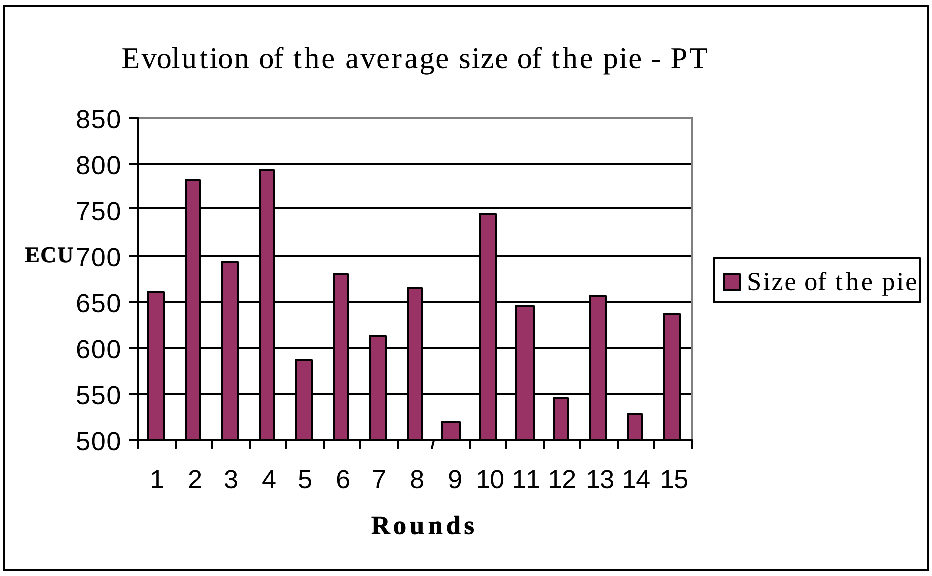

Figure 3. Evolution of the average size of the pie in the partner treatment

These observations therefore seem to point to the fact that most principals do not care about fairness. They try to enforce cooperation with q =0.5 and worry about the shrinking size of the pie, just around the middle of the game, due to the offer of unfair contracts (from rounds 6 to 9, unfair contracts represent 46% of contracts with q =0.5, and more than one third of the total contracts offered). But even though fair contracts offered at round 10 help to increase the average size of the pie, they are nevertheless proposed too late to be considered as a sign of trustful cooperation. Consequently, at the end of the game (rounds 12 to 15), the proportion of fair contracts collapses and the value of *e* increases, a classical effect of end game.

Finally, a total of 108 contracts have then been accepted. But just note that if, in the partner treatment as in the stranger treatment, all contracts offered with q=0.25 are accepted, a smaller proportion of contracts offered with q=0.5 are here accepted (81.5% versus 95% in the stranger treatment). This has something to do with the strategies of some agents that use contract rejection not only as a punishment device but also as an incentive one.

Team cooperation: Team cooperation is globally less developed in the partner treatment (16% of accepted contracts) than in the stranger treatment (see Table 3). A c^2 test rejects the null hypothesis at a level of α=0.01 for q=0.25 and at a level of α=0.15 for q=0.5. Only associated with low levels of suggested effort (*e*<10 with q=0.25 and *e*<12 with q=0.5), team cooperation is indeed never achieved with unfair contracts.

# cases	*Suggested effort (e)*												Total
	2	4	6	8	10	12	14	16	18	20	22	24	
q=0.25													
Accepted contracts	2		1		2	12	3	1	1	2		15	39
Team cooperation	2		1		0	0	0	0	0	0		0	3
q=0.5													
Accepted contracts	5	5	4	4	5	6	9	1	3	5	7	15	69
Team cooperation	5	4	3	1	1	0	0	0	0	0	0	0	14

Table 3. The extent of team cooperation in the partner treatment

Such a lack of team cooperation is explained by most of the principals' behavior, trying to enforce cooperation with q=0.5 at the beginning of the game. Generally not considered as a sign of trustful cooperation, only 3 out of the 39 proposed fair contracts lead to team cooperation.

Coordination failures and payoffs: Table 4 displays the distribution of groups' payoffs. A look at subjects' behavior in some groups illustrates the difficulties to achieve coordination. Two particular groups are here chosen : Group 1 which exhibits a failure of coordination with a genuinely kind principal and Group 3 that exhibit the same failure with a greedy principal.

Group	*Average suggested effort*	*Frequency of theta=0.25*	*Frequency of punishment*	*Average Y1's effort*	*Average Y2's effort*	*Average pie*	*Average principal's payoff*	*Average Y1's payoff*	*Average Y2's payoff*
All con-tracts	15.2	39	22	7.7	12.3	650	226	172	156
1	18.8	8	2	12.4	10	585	159	121	152
2	14.7	1	3	8	9	591	224	144	153

3	18	1	5	8.9	14	743	305	177	167
4	21.7	4	3	5.8	17.2	686	230	175	141
5	7.2	3	2	7.9	12.5	695	274	221	165
6	12.3	14	2	4.5	14.8	710	205	239	184
7	12	2	1	5.8	7.5	500	162	128	121
8	17.3	6	4	9.3	12.7	689	245	174	167

Table 4. Distribution of payoffs in groups

- Let us first consider Group 1, the worst but one in terms of average pie. Figure 4 displays subjects' behavior.

Over the five first rounds, two out of the three subjects (the principal and agent *Y1*) try to set up a coordination on q=0.25 and e=24. But agent *Y2* defects by playing a low level of effort. Such a behavior triggers a retaliation war. It is interesting here to note that such a war takes place precisely between those two subjects that first agree on coordination. At round 5, partly for inciting the other agent to raise his contribution, *Y1* defects (horizontal punishment). The principal retaliates by proposing an unfair contract in the next two rounds (vertical punishment) and this leads *Y1* to reject both offers. Afterwards, fair offers cannot prevent *Y1* to defect, then to reject the proposed contracts with q=0.5 at rounds 13 and 14. Finally, the principal enforces punishment in the last round.

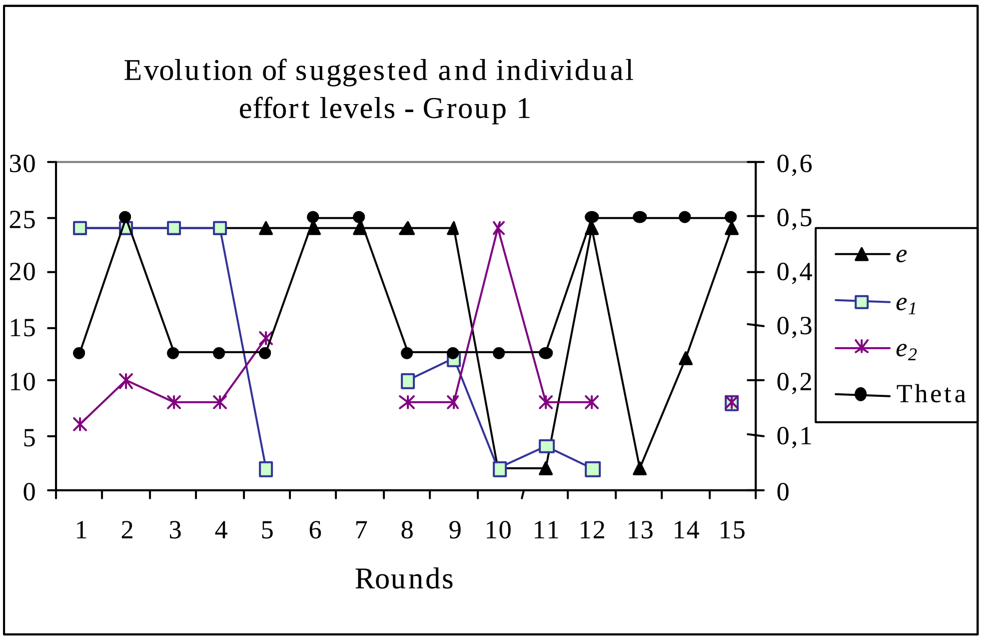

Figure 4. Evolution of subjects' behavior in Group 1

- By contrast, let us consider Group 3, which achieved the best average pie (Figure 5).

Efficiency can be here explained by a generalized lack of reciprocity concern. First of all, except at round 10, it should be noted that the greedy principal ever uses her first mover advantage by choosing q =0.5 and suggesting on the average a high level of effort (9 unfair contracts over 15 rounds).

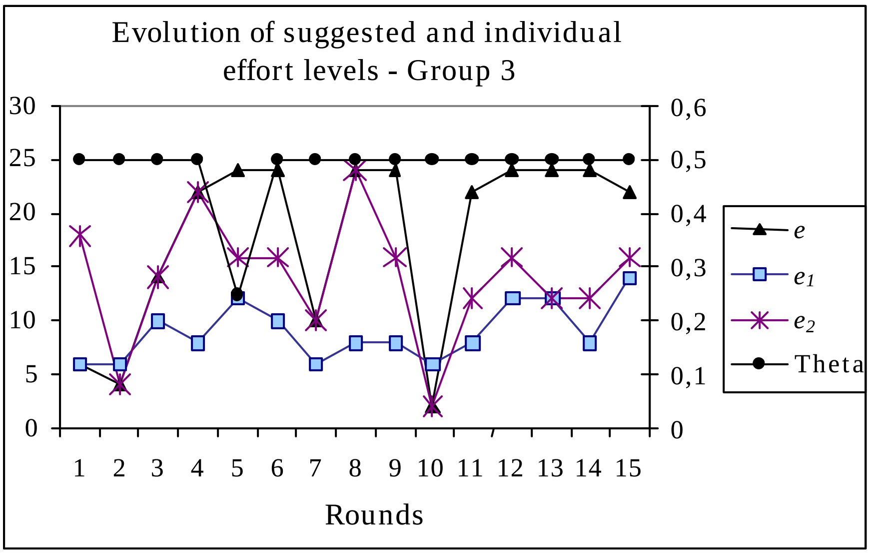

Figure 5. Evolution of subjects' behavior in Group 3

In addition, she mostly enforces punishment (at rounds 3, 4, 6, 11 and 15) with unfair contracts (4 out of 5 cases of punishment enforcement). One should note more generally that this strategy is also observed in other groups. In the aggregate, punishment is applied in 37% of unfair contracts, in 18% of other contracts with q=0.5. In that group, agents do not seem to bother about reciprocation. There is no contract rejection despite the number of unfair contracts; agent *Y1* free rides (and he continues to do so even after a punishment) on the high productivity of agent *Y2* who, in turn, tries not to get a reduced payoff by choosing on the average a level of effort greater than *Y1*'s one.

V. CONCLUSION

Much experimental evidence has established, on the one hand, the importance of incentive to free-ride in groups and, on the other hand, the extent of fairness and reciprocity in one principal – one agent relationships. Distinctively, this paper considers a principal – multi-agent relationship and tries to determine whether principal's fairness helps in limiting the extent of free-riding within a team.

Two repeated game experiments have been run that help to study how team cooperation and free-riding develop in principal – multi-agent sequential move games. Experimental evidence shows that vertical fairness favors horizontal fairness between agents and thus efficiency in the stranger treatment. However, a repeated interaction between same subjects need not improve team cooperation.

One should first note that the results of our partner treatment are close to the evidence displayed by public goods experiments on individual behavior within groups. In such experiments, the level of individual contributions to the funding of a public goods declines over time to the free-riding equilibrium, mainly due to the coexistence of free-riders and conditional cooperators. However, when a punishment device is introduced in such experiments, individual contributions raise over time and converge progressively to the greatest possible level of contribution (Fehr and Gächter, 1999). Distinctively, in our experiment, the punishment mechanism does not succeed in raising team cooperation, because of its asymmetric nature. There is no explicit horizontal punishment mechanism enabling a mutual monitoring within the team and the vertical mechanism that should favor team cooperation is not efficient in a repeated interaction because of its asymmetry: When the threat is credible, the more productive agent has an interest in free-riding in order to trigger the punishment and, thus, to increase his payoff.

One should also note that less cooperation is observed here than in a one principal – one agent framework because of the incentives to free-ride in a team production process. One of our main results is that a fruitful and long-lasting cooperation between principal and team-mates is all the more difficult to achieve with people differently motivated by fairness. Team cooperation occurs in our experiment if and only if two conditions are met. First, team cooperation requires that the principal offers a fair contract and does not apply the punishment that could trigger the more productive agent's free-riding. Second, team cooperation implies that the more productive agent should accept the equal sharing TPS in spite of his higher contribution to the outcome. In such a way, cooperation is more demanding since fairness must develop between agents and not only between one principal and one agent. In such an asymmetric principal – multi-agent relationship, the lack of cooperation in repeated interactions is due to the fact that selfish considerations easily dominate fairness.

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APPENDIX

SHARING RULE : TPS-1

A1- $q = 0.25$

Table 1 – Player Y1's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	126	144	162	180	198	216	234	252	270	288	306	324
4	132	150	168	186	204	222	240	258	276	294	312	330
6	136	154	172	190	208	226	244	262	280	298	316	334
8	138	156	174	192	210	228	246	264	282	300	318	336
10	138	156	174	192	210	228	246	264	282	300	318	336
12	136	154	172	190	208	226	244	262	280	298	316	334
14	132	150	168	186	204	222	240	258	276	294	312	330
16	126	144	162	180	198	216	234	252	270	288	306	324
18	118	136	154	172	190	208	226	244	262	280	298	316
20	108	126	144	162	180	198	216	234	252	270	288	306
22	96	114	132	150	168	186	204	222	240	258	276	294
24	82	100	118	136	154	172	190	208	226	244	262	280

Table 2 – Player Y2's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	126	141	154	165	174	181	186	189	190	189	186	181
4	135	150	163	174	183	190	195	198	199	198	195	190
6	144	159	172	183	192	199	204	207	208	207	204	199
8	153	168	181	192	201	208	213	216	217	216	213	208
10	162	177	190	201	210	217	222	225	226	225	222	217
12	171	186	199	210	219	226	231	234	235	234	231	226
14	180	195	208	219	228	235	240	243	244	243	240	235
16	189	204	217	228	237	244	249	252	253	252	249	244
18	198	213	226	237	246	253	258	261	262	261	258	253
20	207	222	235	246	255	262	267	270	271	270	267	262
22	216	231	244	255	264	271	276	279	280	279	276	271

24	225	240	253	264	273	280	285	288	289	288	285	280

Table 3 - Player X's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	118	130	142	154	166	178	190	202	214	226	238	250
4	124	136	148	160	172	184	196	208	220	232	244	256
6	130	142	154	166	178	190	202	214	226	238	250	262
8	136	148	160	172	184	196	208	220	232	244	256	268
10	142	154	166	178	190	202	214	226	238	250	262	274
12	148	160	172	184	196	208	220	232	244	256	268	280
14	154	166	178	190	202	214	226	238	250	262	274	286
16	160	172	184	196	208	220	232	244	256	268	280	292
18	166	178	190	202	214	226	238	250	262	274	286	298
20	172	184	196	208	220	232	244	256	268	280	292	304
22	178	190	202	214	226	238	250	262	274	286	298	310
24	184	196	208	220	232	244	256	268	280	292	304	316

A2- $q = 0.5$

Table 4 - Player Y1's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	117	129	141	153	165	177	189	201	213	225	237	249
4	120	132	144	156	168	180	192	204	216	228	240	252
6	121	133	145	157	169	181	193	205	217	229	241	253
8	120	132	144	156	168	180	192	204	216	228	240	252
10	117	129	141	153	165	177	189	201	213	225	237	249
12	112	124	136	148	160	172	184	196	208	220	232	244
14	105	117	129	141	153	165	177	189	201	213	225	237
16	96	108	120	132	144	156	168	180	192	204	216	228
18	85	97	109	121	133	145	157	169	181	193	205	217
20	72	84	96	108	120	132	144	156	168	180	192	204
22	57	69	81	93	105	117	129	141	153	165	177	189
24	40	52	64	76	88	100	112	124	136	148	160	172

Table 5 - Player Y2's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	117	126	133	138	141	142	141	138	133	126	117	106
4	123	132	139	144	147	148	147	144	139	132	123	112
6	129	138	145	150	153	154	153	150	145	138	129	118
8	135	144	151	156	159	160	159	156	151	144	135	124
10	141	150	157	162	165	166	165	162	157	150	141	130
12	147	156	163	168	171	172	171	168	163	156	147	136
14	153	162	169	174	177	178	177	174	169	162	153	142
16	159	168	175	180	183	184	183	180	175	168	159	148
18	165	174	181	186	189	190	189	186	181	174	165	154
20	171	180	187	192	195	196	195	192	187	180	171	160
22	177	186	193	198	201	202	201	198	193	186	177	166
24	183	192	199	204	207	208	207	204	199	192	183	172

Table 6 - Player X's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	136	160	184	208	232	256	280	304	328	352	376	400
4	148	172	196	220	244	268	292	316	340	364	388	412
6	160	184	208	232	256	280	304	328	352	376	400	424
8	172	196	220	244	268	292	316	340	364	388	412	436
10	184	208	232	256	280	304	328	352	376	400	424	448
12	196	220	244	268	292	316	340	364	388	412	436	460
14	208	232	256	280	304	328	352	376	400	424	448	472
16	220	244	268	292	316	340	364	388	412	436	460	484
18	232	256	280	304	328	352	376	400	424	448	472	496
20	244	268	292	316	340	364	388	412	436	460	484	508
22	256	280	304	328	352	376	400	424	448	472	496	520
24	268	292	316	340	364	388	412	436	460	484	508	532

SHARING RULE : TPS-2

A3- $q = 0.25$

Table 7- Player Y1's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	105	117	129	141	153	165	177	189	201	213	225	237
4	108	120	132	144	156	168	180	192	204	216	228	240
6	109	121	133	145	157	169	181	193	205	217	229	241
8	108	120	132	144	156	168	180	192	204	216	228	240
10	105	117	129	141	153	165	177	189	201	213	225	237
12	100	112	124	136	148	160	172	184	196	208	220	232
14	93	105	117	129	141	153	165	177	189	201	213	225
16	84	96	108	120	132	144	156	168	180	192	204	216
18	73	85	97	109	121	133	145	157	169	181	193	205
20	60	72	84	96	108	120	132	144	156	168	180	192
22	45	57	69	81	93	105	117	129	141	153	165	177
24	28	40	52	64	76	88	100	112	124	136	148	160

Table 8 – Player Y2's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	111	132	151	168	183	196	207	216	223	228	231	232
4	123	144	163	180	195	208	219	228	235	240	243	244
6	135	156	175	192	207	220	231	240	247	252	255	256
8	147	168	187	204	219	232	243	252	259	264	267	268
10	159	180	199	216	231	244	255	264	271	276	279	280
12	171	192	211	228	243	256	267	276	283	288	291	292
14	183	204	223	240	255	268	279	288	295	300	303	304
16	195	216	235	252	267	280	291	300	307	312	315	316
18	207	228	247	264	279	292	303	312	319	324	327	328
20	219	240	259	276	291	304	315	324	331	336	339	340
22	231	252	271	288	303	316	327	336	343	348	351	352
24	243	264	283	300	315	328	339	348	355	360	363	364

Table 9 - Player X's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	106	118	130	142	154	166	178	190	202	214	226	238
4	112	124	136	148	160	172	184	196	208	220	232	244
6	118	130	142	154	166	178	190	202	214	226	238	250
8	124	136	148	160	172	184	196	208	220	232	244	256
10	130	142	154	166	178	190	202	214	226	238	250	262
12	136	148	160	172	184	196	208	220	232	244	256	268
14	142	154	166	178	190	202	214	226	238	250	262	274
16	148	160	172	184	196	208	220	232	244	256	268	280
18	154	166	178	190	202	214	226	238	250	262	274	286
20	160	172	184	196	208	220	232	244	256	268	280	292
22	166	178	190	202	214	226	238	250	262	274	286	298
24	172	184	196	208	220	232	244	256	268	280	292	304

A4- $q = 0.5$

Table 10 - Player Y1's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	103	111	119	127	135	143	151	159	167	175	183	191
4	104	112	120	128	136	144	152	160	168	176	184	192
6	103	111	119	127	135	143	151	159	167	175	183	191
8	100	108	116	124	132	140	148	156	164	172	180	188
10	95	103	111	119	127	135	143	151	159	167	175	183
12	88	96	104	112	120	128	136	144	152	160	168	176
14	79	87	95	103	111	119	127	135	143	151	159	167
16	68	76	84	92	100	108	116	124	132	140	148	156
18	55	63	71	79	87	95	103	111	119	127	135	143
20	40	48	56	64	72	80	88	96	104	112	120	128
22	23	31	39	47	55	63	71	79	87	95	103	111
24	4	12	20	28	36	44	52	60	68	76	84	92

Table 11 – Player Y2's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	107	120	131	140	147	152	155	156	155	152	147	140
4	115	128	139	148	155	160	163	164	163	160	155	148
6	123	136	147	156	163	168	171	172	171	168	163	156
8	131	144	155	164	171	176	179	180	179	176	171	164
10	139	152	163	172	179	184	187	188	187	184	179	172
12	147	160	171	180	187	192	195	196	195	192	187	180
14	155	168	179	188	195	200	203	204	203	200	195	188
16	163	176	187	196	203	208	211	212	211	208	203	196
18	171	184	195	204	211	216	219	220	219	216	211	204
20	179	192	203	212	219	224	227	228	227	224	219	212
22	187	200	211	220	227	232	235	236	235	232	227	220
24	195	208	219	228	235	240	243	244	243	240	235	228

Table 12 - Player X's payoffs

Effort Y2 Y1	2	4	6	8	10	12	14	16	18	20	22	24
2	112	136	160	184	208	232	256	280	304	328	352	376
4	124	148	172	196	220	244	268	292	316	340	364	388
6	136	160	184	208	232	256	280	304	328	352	376	400
8	148	172	196	220	244	268	292	316	340	364	388	412
10	160	184	208	232	256	280	304	328	352	376	400	424
12	172	196	220	244	268	292	316	340	364	388	412	436
14	184	208	232	256	280	304	328	352	376	400	424	448
16	196	220	244	268	292	316	340	364	388	412	436	460
18	208	232	256	280	304	328	352	376	400	424	448	472
20	220	244	268	292	316	340	364	388	412	436	460	484
22	232	256	280	304	328	352	376	400	424	448	472	496
24	244	268	292	316	340	364	388	412	436	460	484	508