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INCENTIVE DESIGN WITH RECIPROCAL AGENTS

Direttore della Scuola: Ch.mo Prof. Guglielmo Weber

Supervisore: Ch.mo Prof. Antonio Nicolò

Dottoranda: Natalia Montinari

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Para ser grande, sê inteiro: nada
Teu exagera ou exclui.
Sê todo em cada coisa. Põe quanto és
No mínimo que fazes.
Assim em cada lago a Lua toda
Brilha, porque alta vive.

(Ricardo Reis 14-2-1933)
Fernando Pessoa

To my mother
To the mother of my mother

To Luca and Tommaso

Acknowledgements

"The happy man does need friends"

Aristotele,
The Nicomachean Ethics, Book IX

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Contents

Introduction

Incentive Design with Reciprocal Agents

This thesis is about incentive design in presence of agents who exhibit reciprocity and it is composed by four papers, each corresponding to a self-contained chapter. The first one presents a theoretical analysis of the optimal compensation scheme design in presence of workers who are motivated both by reciprocity toward the principal and the colleagues. The third and the fourth ones apply the methodology of laboratory experiment to investigate, respectively, the presence of spillovers effects across alternative incentive systems and a different but simultaneous social dilemma; and the relevance of (useless) peer information under a piece rate incentive scheme in which workers can observe each other. Finally, the last chapter empirically analyzes the effectiveness of alternatives incentives designed for waste sorting and recycling and applied in the Treviso district from 1999 to 2008.

In recent years, a growing literature analyzes the factors which impact incentives' effectiveness at individual as well as group level (e.g. organizations, communities, etc). Indeed, besides a considerable number of studies documenting that incentives works (Gibbons, (1997), Lazear (2000)) a recent growing literature reports evidences from field and laboratory experiments about cases in which incentives are not effective (Angrist and Lavy, 2009) or even detrimental, leading to undesired results and crowding-out of intrinsic motivation (see for instance, Ariely et al., 2009; Frey and Oberholzer-Gee, 1997; Gneezy and Rustichini, 2000). In particular, it is not obvious that incentives designed under the assumption that individuals are self interested, result equally effective even in those cases in which agents exhibit other regarding preferences, Gintis et al. (2005). If incentives and motivations are substitute, incentives results to be ineffective or even counterproductive. In these situations we observe the so called *crowding out* of intrinsic motivation or *over-justification effect*, Bénabou and Tirole,

(2003). Symmetrically, incentives may reinforce intrinsic motivation, acting as a complement, as documented by Bowles (2010), Galbiati and Vetrova (2009).

In the first chapter we analyze a principal two agents model. Relying on the relevance of other-regarding preferences in workplaces, the chapter provides a behavioral explanation for the extra-effort provision in organizations (i.e. overtime, additional task, etc) when workers exhibit horizontal reciprocity concerns. In particular the chapter shows that a profit maximizing employer may find it convenient to offer employees a relative compensation scheme, which, by exploiting negative horizontal reciprocity, induces extra effort exertion but does not pay any monetary compensation in equilibrium. This result is robust to the introduction of vertical reciprocity concerns which cannot be neglected in many organizations.

Chapter 2 contains a laboratory experiment which investigates how different incentive systems interact with individuals' willingness to cooperate in social dilemmas, highlighting the mechanisms which induce crowding out of voluntary cooperation. In particular the chapter investigates the impact of different incentives on simultaneous public good contributions in economically unrelated games. The results show that tournaments, but not simple piece rate schemes, reduce contributions by about 40%. However, the effect is brittle. The incentivized elicitation of beliefs eliminates the effect. It also vanishes immediately if the games are played sequentially rather than simultaneously. Therefore, the designers of competitive incentive schemes must pay close attention to the framing of the scheme in order to avoid negative spillovers.

Chapter 3 presents results from a laboratory experiment which tests the impact of peers' effect on individual productivity under piece rate incentives. Along 15 repetitions, being informed about their productivity, participants choose an initial effort level which they can revise after a feedback on result. Knowing that the optimal effort choice may differ across subjects, half of the participants received also a feedback about the initial choice and the results of another participant in the room without knowing her/his productivity. Despite the fact that information about peer is useless in determining the individual optimal effort, we find that individuals manifest *selective attention* to information about peer. In particular, those subjects informed that the peer obtained a higher result have a higher probability to revise their initial choice and a higher probability to revise it optimally.

The fourth chapter is an empirical analysis of the effectiveness of incentives for waste recycling. We use data on the amount of waste produced in each of the 95 municipalities in the district of Treviso (Italy) for the period 1999-2008. The specificity of local regulative frame has

created conditions for a quasi-natural experiment. Our dataset is unique for three reasons. First, in our sample the incentive mechanism is randomly assigned to the municipalities. Second, our data show wide heterogeneity of policies over the years. Third, its panel structure allows us to control for potential increasing concern for the environment, and to isolate potential "learning effects" of incentives over time. We find that the introduction of economic incentives has a significant and positive net effect of around 12% on the recycling waste ratio, that is complementary to the positive effect induced by door-to-door collection. The effect of PAYT is obtained by increasing the production of sorted waste (+10%), while the production of total waste remains unchanged. We therefore conclude that economic incentives are an effective tool to reach the desired goal.

References

1. Benabou, R., Tirole, J., 2006. Incentives and prosocial behavior. American Economic Rewiew 96 (5), 1652–1678.

2. Bowles (2009), Policies Designed for Self-Interested Citizens May Undermine 'The Moral Sentiments': Evidence from Economic Experiments. *Science* 320 (2008): 5883 (June 20).

3. Lazear, E., 2000. Performance pay and productivity. American Economic Rewiew 90 (5), 1346–1361.

4. Gintis, H., Bowles, S., Boyd, R., Fehr, E. (Eds.), 2005. Moral sentiments and material interests: the foundations of cooperation in economic life. MIT Press, Cambridge.

Chapter 1

The dark side of Reciprocity

CHAPTER PREVIEW: Relying on the relevance of other-regarding preferences in workplaces, we provide a behavioral explanation for the extra-effort provision in organizations (i.e. overtime, additional task, etc) when workers exhibit horizontal reciprocity concerns. We characterize the optimal compensation scheme for a selfish employer that induces unpaid or underpaid extra-effort under both symmetric and asymmetric information about workers' action. We show that our result is robust to the introduction of vertical reciprocity concerns.

1.1. Introduction

In many situations employees exert extra-effort working overtime or accepting to carry out tasks which are not included in their job contract. In particular, unpaid overtime seems quite common in modern industrialized societies. For instance, in 2001 the average European wage-earner was compensated for only about 5 out of 9 hours worked overtime per week (Eurostat, 2004). In Canada, the percentage of employees working overtime increased from 18.6% in 1997 to 22.6% in 2007 and the 11.4% of overtime in 2007 was worked unpaid (Statistics Canada, 2008). Similar pictures characterize Australia, Japan and US (Mizunoya, 2001). Workers may decide to exert extra-effort attempting to improve their future positions, typically through promotions or career advances. However, very often extra effort does not lead to better job conditions, (Booth et *al.*, 2003 and Meyer and Wallette 2005). Moreover the possibility of future advances in career is only a partially satisfactory explanation, given the considerable amount of unpaid overtime reported by workers at the end of their career or at the top of their organization's hierarchy (Pannenberg, 2005).

We offer a complementary explanation to the extra-effort exertion focused on the role of workers' other regarding preferences in highly competitive work environments. In particular we develop a principal multi-agents model in which agents' reciprocity concerns both toward colleagues and principal interact with the incentive scheme, determining the workers' decision to exert or not extra effort. The workplace, indeed, is characterized by high density of social relationships which concur in determining the effectiveness of incentives scheme for achieving organizational goals (Rotemberg, 2006). However, the nature of social interactions is ambivalent. For instance, on the workplace, one may develop new friendships which have a positive impact on job satisfaction (Clark, 2005), while in other circumstances s/he may feel stressed by the extreme competition among colleagues or by peer pressure (Heywood et al., 2005) and -in extreme cases- s/he can experience sabotage by colleagues (Lazear 1989). Whether friendships and positive social interactions rather than competitive relationships deserve to be encouraged in achieving organizational goals it is not obvious *a priori*. As discussed by Heywood et al. (2005) it should rather depend on job attributes and organizational characteristics and moreover, it must account for the empirically observed workers´ tendency to self-select in different organizations depending on the power of the incentive schemes adopted (Delfgaauw and Dur, 2008; Eriksson and Villeval, 2008).

In this paper we derive the conditions under which managers find convenient to offer highly competitive compensation schemes to workers motivated by reciprocity even if those incentives may be perceived as unfair by the workers and/or may result in negative relationships between colleagues. Our main result is that employees' vertical and horizontal reciprocity concerns may be exploited to elicit extra-effort without full compensation. The optimal mechanism, indeed, is a relative compensation scheme which in equilibrium induces extra effort provision and, by exploiting workers' negative reciprocity, it does not pay any monetary compensation. In particular, the optimal compensation scheme promises a high monetary payment to the worker who exerts extra-effort when the colleague refuses to do so and no compensation otherwise. Therefore, once this scheme is offered, the worker who chooses to exert extra-effort prevents the colleague from gaining his/her highest monetary compensation. In this way, s/he induces the colleague's negative orientation toward her/him. It follows that a worker motivated by negative reciprocity is willing to undertake underpaid (or unpaid) extra-effort in order to punish the colleague by preventing him/her gaining from being the only one exerting extra-effort. In particular, even when only the joint extra-effort exerted but not the individual action is observable, the compensation scheme offered by the managers traps the workers in a situation which resembles a prisoner dilemma. Every worker exerts extra-effort in order to avoid the situation in which the colleague is the only doing it, whereas would be better for both

workers not exerting extra effort at all.

Van Echtelt et al. (2007), on analyzing the Time Competition Survey on a sample of Dutch firms, find that work pressure (defined as workers' negative motivation) is predictive of spending additional unpaid hours at work. Moreover, this result seems also to match job habits in financial and professional services where strong work pressure induces extreme time competition among employees which resembles a "rat race", (Landers et al., 1996).

We first consider the case in which agents exhibit horizontal reciprocity and then we also include vertical fairness. In fact, if vertical reciprocity may be plausibly ignored in contexts where social distance between the employer and the workers is high, as large firms, (Henning-Schmidt et al., 2010), in our setting it may affect the result. In particular, workers may consider the relative compensation scheme as an unfair offer. Consequently, in presence of vertical reciprocity, the employer, anticipating the workers' negative reaction, may prefer to offer a different compensation scheme than the relative one.

We introduce vertical reciprocity in the workers' utility function by allowing the employer to choose between a relative and an individual compensation schemes. Despite several authors have evidenced the existence of multiple fairness norms in organizations, their potential interactions has not been extensively analyzed yet (Alewell et al., 2007). Therefore, we consider two extreme scenarios. In the first one, we assume additivity of vertical and horizontal reciprocity concerns. In this case, the optimal compensation scheme does not change; the only difference is that, for the case in which only one worker exerts extra effort, the manager has to promise an higher compensation than in the case where only horizontal reciprocity is present. In the second case, we assume that horizontal and vertical reciprocity are mutually exclusive, as evidenced in Eisenkopf and Teyssier (2009). In this case there are conditions under which a profit maximizer employer still prefers a relative compensation scheme (inducing negative reciprocity) to an individual compensation scheme (inducing positive reciprocity).

Finally, by including fairness concerns about workers in to the employer's utility function; we derive the conditions under which an individual compensation scheme inducing positive vertical reciprocity is preferred to a relative compensation scheme.

Our results crucially depend on the presence of workers' reciprocity concerns. Extra effort, indeed, may be elicited from standard agents through adequate compensation schemes. However, while compensation schemes designed for standard agents need to pay positive monetary compensation in equilibrium in order to induce extra effort, in our model, the presence of workers' reciprocity concerns makes optimal a compensation scheme which does not pay any monetary prize in equilibrium.

The paper is organized as follows. Section 2 briefly discusses the related literature and the contribution of this paper to it. Section 3 illustrates the model and discusses the definition of horizontal reciprocity. Section 4 characterizes the optimal contract under both symmetric and asymmetric information. Section 5 presents some extensions to the base model. Section 6 introduces vertical reciprocity concerns. Section 7 concludes. All the proofs are in the Appendix.

1.2. Related Literature

Our results add to a recent literature investigating how organizations can motivate workers by substituting social to monetary incentives (Bandiera et al., 2009; Dur and Sol, 2010; Rey Biel, 2008). Designing effective incentive schemes has a crucial relevance in determining the success of an organization. Recent empirical evidence, both from laboratories and fields, has assessed the existence and the relevance of other-regarding preferences as motivator in human behavior. In workplaces, as well as in other contexts, individuals are not motivated solely by self interest but they also care - positively or negatively - about material payoffs from relevant others whom they choose as referents[1]. Therefore, as already pointed out by Milgrom and Roberts (1992), in designing incentive system, other-regarding preferences deserve to be adequately taken in account. Workers' effort choices, indeed, may be affected not only by the monetary compensation but also by the way in which other-regarding preferences respond to own and other workers' payoffs. Intrinsic motivation crowding-out (Gneezy and Rustichini, 2000), and over-justification effects (Bénabou and Tirole, 2006) are some of the most known examples of unexpected negative effects resulting from mistakes in the incentive systems design.

We focus on reciprocity which identifies the willingness to respond fairly to kind action and unfairly to nasty actions (Rabin, 1993). Reciprocity seems to be one of the most relevant factor in motivating workplace behaviors (Akerlof, 1928). We concentrate first on *horizontal* reciprocity[2] in order to capture what, according to the Social Comparison Theory, is a natural tendency: people make comparisons, especially to others having the same status as themselves (Festinger, 1954). Differently

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[1]Fehr and Fischbacher, (2002) and Rotemberg, (2006) review respectively experimental and theoretical results on other-regarding preferences in the workplace.
[2]Vertical reciprocity has been extensively analyzed since the seminal paper by Akerlof, (1982). For a survey of experimental results see Fehr and Gächter, (2002).

from vertical fairness, indeed, reciprocity among peers has not been extensively analyzed in the workplace. Studies on other-regarding preferences among peers have focused theoretically and empirically on *peer pressure* (Kandel and Lezaer, 1992; Mas and Moretti, 2009), *conformism* (Gächter and Töni, 2009), *inequity aversion* (Rey Biel, 2008; Englmaier and Wambach, 2010), *social interactions* (Dur and Sol, 2010) and *altruism* (Rotemberg, 1994), but not specifically on reciprocity among colleagues. Moreover, mutual-help among employees (Corneo and Rob, 2003), the social sanctioning of free riders (Carpenter and Matthews, 2009), and social support among co-workers (Mossholder et al., 2005) may be interpreted as manifestations of reciprocity. In the workplace, it seems evident that repetitive interactions and team work create an environment in which each worker may affect the team's activity and the compensation of other team members if team bonuses are included in the individual worker's compensation. In contexts of this kind, horizontal reciprocity matters because each worker compares what he (and other team mates) earns with what he would have obtained as a consequence of an alternative choice by his colleagues.[3]

We model reciprocity as in Cox et al. (2007), where distribution of the material outcomes and the kindness (unkindness) of others' choices (intentions) affect a person's emotional state. The emotional state, then, determines the marginal rate of substitution between own and others' payoffs and the person's subsequent choices. Differently from the approaches where reciprocity is modeled in terms of beliefs regarding intentions (Rabin 1993), the Cox et al. (2007)'s formulation defines reciprocity in sequential games where the fairness judgment is essentially based on actual behaviors rather than on belief and expectations. Therefore, this formulation gains in tractability but it still captures the relevance of intentions, since the distribution of material outcomes are intended as revealing the others' intentions. Consistently with Cox et al.'s (2007), in our sequential model, the fairness of the colleague's strategy is evaluated by looking at its material consequences on the worker's utility function[4], on the conviction that, at least in workplaces, it is actual behaviors more than beliefs and expectations driving the reciprocal response between workers.

Results similar to ours have been obtained in a different framework by the theoretical studies of Rey-Biel (2008) and Dur and Sol (2009). In Rey-Biel (2008), a profit maximizer employer exploits the inequity aversion of his/her workers to induce effort without fully compensating its cost, still offering a relative performance contract. However, in Rey-Biel's paper, workers derive disutility from

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[3]In Kahneman et al. (1986) this definition refers to a comparison between what the worker (and other team mates) earns and what s/he thinks s/he (and other team mates) is entitled to.

[4]Appendix A1 discusses Cox et al.'s (2007) formulation and derives the ones used here. For a discussion on the role of belief s and expectations as well as real behavior in conceptualizing reciprocity, see Perugini et. al., (2003).

differences between themselves and others, while in our model workers are not interested in the relative final payoff rank per se, but instead use it as a reference for the co-worker's fairness evaluation. In our framework, indeed, the worker evaluates the colleague's fairness by comparing the material consequences of the chosen strategy against those of the strategy which is not chosen. Moreover, while Rey-Biel (2008) does not consider workers' other regarding preference toward the principal, we include them in the analysis, since it is reasonable to assume that in some work contexts; employees form a judgment about the fairness or the equity of the employer's offer.

Our paper proposes a complementary perspective to the one provided by Dur and Sol (2010) who have showed the circumstances in which it may be in the interest of the managers to encourage friendship formation between employees in order to attract and retain workers. In their model, indeed, workers can devote part of their effort to social interaction with their colleagues. In equilibrium, positive reciprocity arises because a worker treated kindly will care more about the wellbeing of his/her colleagues. This implies an increase in job satisfaction which off-sets lower wages. As in our model, monetary incentives and other-regarding preferences are substitute means that an employer may use in order to obtain a certain output, but the characterization of reciprocity is different. In the model used here, reciprocity relates to what happens in the workplace (and hence is deeply affected by the incentive system), while in Dur and Sol's (2009) model being kind means showing "interest in the colleague's personal life, offering a drink after working hours...", (p. 2). Consequently, while Dur and Sol model captures the case in which workers' positive social relations at work are also beneficial for the manager, we characterize a situation in which the manager finds convenient to let workers to compete even at the cost of deteriorating the workplace social relationships.

Finally, we show that horizontal reciprocity may furnish a rationale for the composition of teams of workers, even when the production technology induces negative externality among the workers' efforts. Gould and Winter (2009) show that the presence of strategic interdependencies among the workers' actions affects the worker's action choice. In their model, depending on the value of the project, a employer may find it optimal to employ only one worker or two in the presence of strategic substitutability of the production technology. We show that workers' reciprocity is a reason for composing teams of two workers in situations where one standard worker would be employed. Our result is based on the endogenous complementarity (Potter and Suetens, 2009) among workers' actions induced by reciprocity which mitigates the impact of the negative externalities imposed on the workers by the production technology.

1.3. The Model

We model extra-effort provision in a frame where a risk-neutral employer (P) engages a team of two risk neutral workers: A_i, with $i \in \{1,2\}$, where the index refers to the timing of the worker's action[5]. The employer and the workers contract some activities additional to those included in the job contract, typically an *extra-task* or *overtime*. For this reason we assume the participation constraints have been satisfied[6]. The employer asks each worker to undertake *extra-effort*. Let $a_i \in \{0,e\}$ with $i = 1,2,$ be the worker's decision, where $a_i = 0$ and $a_i = e > 0,$ indicate whether the worker refuses to undertake extra-effort or not. The cost of undertaking extra-effort is $c(e) = c > c(0) = 0.$ We assume that workers are identical with respect to productivity and disutility of effort and that they can observe their colleagues' choice. Finally let $X(\gamma, a_i, a_j) = \gamma(a_i + a_j)$ be the production function.[7] The timing of the extra-effort game is as follows: at $t = 0$ the employer offers a compensation scheme for the extra-effort provision: $w_i(a_i, a_j)$, for $i, j = \{1,2\}$ and $i \neq j$. At $t = 1,$ worker 1, having observed the compensation scheme, decides whether or not to exert extra-effort. At $t = 2$ worker 2, having observed both the compensation scheme and the action chosen by the team mate, chooses a_2. Finally production is realized and compensations are paid. We solve the game by backward induction. The employer maximizes the following profit function:

$$\Pi = \gamma(a_i + a_j) - (w_i + w_j) \qquad (1)$$

If $\gamma > \frac{w_i}{e_i}$, with $i = 1,2,$ the employer obtains her highest profit when both workers exert extra-effort. In section (6.4) we modify the principal's profit function, allowing the principal to care about the fairness of the compensation scheme offered to the workers.

Let M_i denotes the worker's *material* payoff that is, the compensation received minus the cost[8] of

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[5]Henceforth, we will assume that the employer is female and that the employees are male.

[6]In the rest of the paper we will use the term `game' to denote the "extra-effort provision game". We assume that there is no interdependence between this game and the "normal working time" game.

[7]We only need to assume that the production function is increasing in agents' effort, and we focus on the case in which employer's profit is maximized when agents exert extra effort. Our results are not affected by the functional form of the production function; therefore, we assume a linear function in order to keep the frame as simple as possible.

[8]We assume that c is the material equivalent of the disutility from extra-effort provision.

exerting extra-effort:

$$M_i(w_i, c_i) = w_i(a_i, a_j) - c_i(a_i) \tag{2}$$

Workers maximize the following utility function:

$$U_i(M_i, M_j, \rho_i^h, r_i) = M_i + \rho_i^h r_{i,\sigma_j} M_j \tag{3}$$

where the exogenous parameter $\rho_i^h \in [0,1]$ measures the impact of horizontal reciprocity concern in worker i's utility function. We define as *standard* those workers with $\rho_i^h = 0$ and who care only about their own material payoff. *Reciprocal* workers are those workers who have $\rho_i^h > 0$ and also care about the colleague's material payoff. The *reciprocity term* r_{i,σ_j} determines the sign (positive or negative) of worker's i reciprocity. Denote by H_i and L_i respectively the highest and the lowest material payoff for A_i. Let σ_j and σ_j' be two strategies of A_j, with $\sigma_j \neq \sigma_j'$. Let $b_i^*(\sigma_j) = \sigma_i^*$ the player i's best response to strategy σ_j chosen by player j, such that

$M(b_i^*(\sigma_j) = \sigma_i^*, \sigma_j) \geq M_i(\sigma_j, \sigma_j)$, $\forall \sigma_i \neq \sigma_i^*$.

The reciprocity term of A_i, given that A_j chooses the strategy σ_j, is defined as follow:

$$r_{i,\sigma_j} = \frac{M_i\left(b_i^*(\sigma_j), \sigma_j\right) - M_i\left(b_i^*(\sigma_j'), \sigma_j'\right)}{H_i - L_i} \in [-1, +1] \tag{4}$$

The reciprocity term in (4) is determined by the difference between the maximum material payoff that A_i can obtain - given the strategy σ_j chosen by A_j - and the maximum material payoff that A_i could have obtained under the alternative strategy choice σ_j'. This difference is then normalized by $H_i - L_i$.[9] When $r_{i,\sigma_j} > 0$, A_i positively evaluates A_j's material payoff. Hence if $M_j > 0$ (<0), it enters A_i's utility function as a positive (negative) *externality*.

The reciprocity term accounts for the *intentionality* of A_j's choices. A_i evaluates A_j's kindness by

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[9] The magnitude of r_{i,σ_j} is determined by the numerator of eq. (4). We assume that $r_{i,\sigma_j} = 0$ if the $H_i = L_i$ is

comparing how the A_j's chosen and not chosen strategies affect his own material payoff.[10] In what follows we design the optimal compensation scheme that an employer should offer to induce workers to exert extra-effort. We accordingly assume that workers are already within the firm and that the participation constraints are satisfied. Nevertheless, to avoid trivial solutions, we assume that the employer cannot trigger her workers with negative compensations, nor promising unlimited compensations even if they are not paid in equilibrium. Hence, we fix a budget $B > 0$ and we assume $w_i \geq 0$, for both $i \in \{1, 2\}$ such that $w_1 + w_2 \leq B$.

1.4. The Optimal Compensation Scheme

In the next subsections we derive the optimal compensation schemes both in the case where the employer observes the workers' actions (subsection 3.1) and in the case where the employer does not observe the individual action but only the final output produced (subsection 3.2). In both subsections 3.1 and 3.2 we assume that the employer observes both the employees' type ρ_i^h, and that employees observe each other's action. Finally, in subsection 3.3 we characterize the optimal compensation scheme that requires the least payment to be offered out of equilibrium.

1.4.1. The Symmetric Information Case

When the employer observes employees' actions, the compensation scheme can be conditional on them. Let us use $w_i^S(a_i, a_j)$ for $i, j = 1, 2$ with $j \neq i$ to denote the optimal compensation scheme for standard workers $(\rho_i^h = 0)$. This scheme will be used as benchmark. The optimal compensation scheme $w_i^S(a_i, a_j)$ is such that, irrespectively of the action chosen by the team mate, each worker receives compensation $w_i^S(e_i, a_j) = c$ if he works extra and $w_i^S(0, a_j) = 0$ otherwise,[11] for both

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equal to 0.

[10]The relevance of *unchosen* alternatives constitutes the main difference with respect to distributional models à la Fehr and Schmidt, (1999), where only the final relative distribution matters, Falk et al. (2003).

[11]This is only one of the several possible optimal compensation schemes. Note that $w_1(e_1, 0)$ and $w_1(0, 0)$ refer to output levels that, given the incentives provided to A_2, are never produced. This implies $w_1(e_1, 0)$ and

$i, j = 1, 2$, with $j \neq i$. The employer pays an amount of compensation equal to $2c$ and obtains $\Pi^S = 2(\gamma e - c)$ as profit.

The following proposition describes the optimal compensation scheme when workers are reciprocal.

Proposition 1 *Under symmetric information and $\rho_i^h > 0$ for $i = 1, 2$ the optimal compensation scheme is a tournament that induces negative horizontal reciprocity. Each worker receives a monetary compensation equal to B if and only if he is the only one exerting extra-effort. In the other case, if $B \geq (\frac{1}{\min\{\rho_i^h, \rho_j^h\}} + 1)c$, he will receive no compensation, while if $B \in \left(0, (\frac{1}{\min\{\rho_i^h, \rho_j^h\}} + 1)c\right]$ then he will be underpaid, receiving a compensation lower than c.*

Proof. See Appendix A2. ∎

The optimal compensation scheme in proposition 1 induces a unique equilibrium in dominant strategies, in which the second mover exerts extra-effort irrespectively of the action of the first mover, and the first mover exerts extra-effort as well.

Figure 1 represents the optimal compensation scheme. The intuition of the result is as follows. Consider worker 2 first. Suppose worker 1 has chosen his action. If worker $2's$ action does not affect worker 1 's material payoff, then worker 2 chooses the action that maximizes his own material payoff.
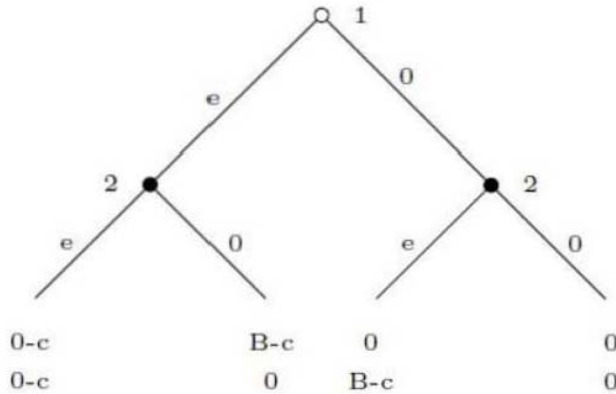

Figure 2.1. The optimal compensation scheme under symmetric information.

$w_1(0,0)$ can take any value in the interval $[0, B]$. Depending on the values specified for each of them, we have different optimal compensation schemes implementing $2\gamma e$ at the cost of $2c$

This is the case when $a_1 = 0.$ If worker 2's action modifies worker 1's material payoff, then worker 2 chooses the action that maximizes his own utility, which is not necessarily the action that gives to him the maximum material payoff. Indeed, in this case horizontal reciprocity plays a role, since worker 1's material payoff enters as an externality into worker 2's utility function. If worker 1 chooses $a_1 = e,$ this prevents worker 2 from gaining his highest material payoff $w_2(0,e_2) = B$ and therefore motivates worker 2 to have a negative attitude toward worker 1. It is for this reason that worker 2 prefers to exert extra-effort even if this action reduces his material payoff.

Since worker 1's extra-effort choice enters in worker 2's utility function as a negative externality and this externality is increasing with the value of $w_1(e_1, 0),$ the employer will find it convenient to fix out of equilibrium the highest possible compensation for $w_1(e_1, 0) = B.$ In this way, worker 2 will prefer to work unpaid extra-effort to avoid such a large negative externality. In fact, if the negative externality is higher than the cost of doing extra effort, worker 2 will work for free in order to avoid the situation of not working extra while worker 1 does so, receiving $w_1(e_1, 0) = B$. On a similar argument, worker 1 anticipates worker 2's behavior and chooses to provide extra-effort as first.

The minimum level of payment that must be offered out of equilibrium to induce unpaid extra-effort is $\underline{B} = (\frac{1}{\min\{\rho_i^h, \rho_j^h\}} + 1)c.$ Note that $\underline{B}$ is increasing with the disutility of effort c and decreasing with $\rho_i^h,$ with $i = 1, 2$. Intuitively, for any given compensation offered out of equilibrium the higher the impact of the workers' horizontal reciprocity concern the easier it becomes for the employer to induce unpaid extra-effort. Note that when ρ_i^h is close to $1,$ meaning that worker i weights the worker j's material payoff almost as his own, the B that must be offered out of equilibrium approximates $2c,$ which is the budget required to induce extra-effort by standard workers. In a similar way, the greater is the disutility of workers' effort, the larger is the B that must be offered to exploit reciprocity concerns.[12]

In our model, if the employer demands extra-effort to both employees, a compensation scheme inducing *positive* reciprocity is always more costly than a compensation scheme offered to standard employees as long as we do not remove the assumption that the principal maximizes a profit function as in eq(1).[13]

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[12]By offering this compensation scheme, the employer puts her workers in a situation similar to a sequential prisoner's dilemma, where each worker is unable credibly to commit to not providing overtime once the colleague has abstained from doing so. Of course, one could reasonably object that a repetition of this game could provide the agents with an incentive for colluding. However, we believe that the one-shot nature of our game better captures the non-regularity of overtime demand.

[13]See Appendix A.3 for a formal proof. In Appendix A.4 we also show that, when the optimal compensation

In addition, note that when the employer is able to observe ρ_i^h, she always prefers to demand extra-effort from reciprocal types because she obtains the highest output at no cost.

Proposition 2. *The employer prefers to employ reciprocal workers rather than standard workers.*

Proof. See Appendix A.5.∎

In the Appendix, we rank the employer's preferences regarding the composition of teams. We show that a team composed of two reciprocal workers is always preferred to a team composed of a standard worker and a reciprocal worker. Hence, a team composed of a standard and a reciprocal worker is always preferred to team composed only of standard workers.

1.4.2. The Asymmetric Information Case

In this section and for the rest of the paper we assume that the employer only observes the employees type ρ_i^h and output level produced by the team.[14] Under asymmetric information a complete compensation scheme specifies the rewards offered to each worker *conditional* on the *total output* and it is profit maximizing. In this regard, three different output levels can be defined: $2\gamma e > \gamma e > 0$, depending on whether, respectively, two workers, one worker, or any worker exert extra-effort. As under symmetric information, we take as benchmark the case with standard workers. In this case, the scheme assigns to each worker compensation equal to $w_i(2\gamma e) = c$, if $2\gamma e$ is produced, and no compensation otherwise.[15] The employer obtains $\Pi^S = 2(\gamma e - c)$ by paying an amount of compensations equal to $2c$.[16]

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scheme designed for standard workers is offered to reciprocal workers, the ORP are neutralized.

[14]There are indeed many situations in which managers cannot monitor workers while the workers can observe each other: for example, in professional jobs and research activities.

[15]As in the symmetric information case, this is only one of the several possible compensation schemes that maximize the employer's profit. Given the incentives provided to A_2, γe is never produced. Hence, depending on the value specified for $w_1(\gamma e) \in [0, B]$ we have different optimal compensation schemes implementing $2\gamma e$ at the cost equal to $2c$.

[16]Note that, since both the employer (principal) and the workers (agents) are risk neutral, under asymmetric information we do not observe loss of efficiency due to the distortion in the risk allocation among the parties.

Proposition 3. *Under asymmetric information, if $\rho_i^h > 0$ for both $i = 1, 2$, then the optimal compensation is an asymmetric payment scheme that induces negative horizontal reciprocity. Worker 1 receives a positive monetary compensation equal to B^A if and only if γe is produced and Worker 2 receives a positive monetary compensation equal to B^A if and only anything is produced. When $B^A \geq \max\left\{ \frac{c}{\rho_1^h}, c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h} \right\}$, the employer obtains $2\gamma e$ without paying any compensation in equilibrium, while when $B^A \in \left(0, \max\left\{ \frac{c}{\rho_1^h}, c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h} \right\} \right)$, she pays a sum of compensations lower than the one required by standard workers.*

Proof. See the Appendix A.6.■

The optimal compensation scheme in proposition 3 induces a unique equilibrium which survives the iterated elimination of dominated strategies. In equilibrium, the second mover undertakes extra-effort in the first subgame but not in the second one, and the first mover exerts extra-effort. The intuition of this result is similar to that for proposition 1. Inspection of Figure 2 shows that the main difference with respect to the symmetric information case is that the employer cannot condition the compensation scheme on the individual actions but only on the output level.
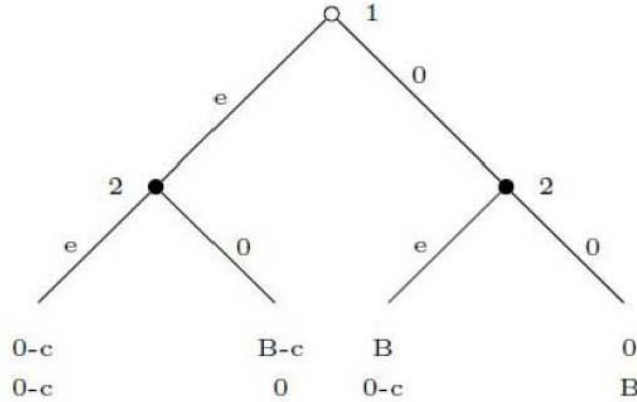
Figure 2.2. The optimal compensation scheme under asymmetric information

Consider worker 2. If A_1 does not exert extra-effort, A_2 will not because this action maximizes his material payoff: $w_2(0) = B^A$. If A_1 will exert extra-effort, A_2 has an incentive to work extra as well. When A_2 is motivated by negative reciprocity, not providing extra-effort (allowing A_1 to gain $w_1(\gamma e) = B^A$) may be even worse than working unpaid. The negative orientation of A_2 follows

from the fact that A_1, by choosing to provide extra-effort rather to abstain, prevents him from obtaining his highest material payoff. The key assumption behind this result is that, while we assume that the employer cannot monitor workers' actions, we still assume that she is able to distinguish reciprocal workers from standard ones. This enables her to offer an information revelation scheme inducing unpaid extra-effort under asymmetric information. Indeed, given that each worker observes the colleague's action, the employer exploits the second mover's reaction to set an information revelation incentive scheme.

The minimum level of payment that the employer must offer out of equilibrium to induce unpaid extra-effort is different for each worker and we denote it $\underline{B}^A = \max\left\{\frac{c}{\rho_1^h}, c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h}\right\}$. Note that $\underline{B}^A$

[17] is increasing in the disutility of effort and decreasing in ρ_i^h, with $i = 1, 2$. This result implies that when workers exhibit identical ρ^h, worker 2 requires the highest payment out of equilibrium to undertake unpaid extra-effort, then $\underline{B}^A = c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h}$. Finally to be noted is that, for both ρ^h tending to 1, the $\underline{B}^A$ that must to be offered out of equilibrium is slightly higher than c, which is actually the standard worker' compensation. As the ρ^h approximate to 0, the $\underline{B}^A$ that must be offered out of equilibrium goes to $+\infty$.

1.4.3. The least budget-demanding optimal compensation scheme

In the previous sections we have assumed the employer has an unlimited amount of money B to offer out of equilibrium. As highlighted above, depending on B, several optimal compensation schemes may be defined. However, it is likely that in some situations (i.e. binding financial constraint) the budget is limited. Since the credibility of the payments fixed out of equilibrium plays a crucial role in our framework, it makes sense to identify the optimal scheme requiring the lowest possible level of B. Let us provide the following definition to such scheme.

Definition 1 *The least budget-demanding (LBD) optimal compensation scheme is the optimal compensation scheme requiring the smallest payment B to be offered out of equilibrium such that both workers undertake unpaid extra-effort.*

In this respect we can show that:

Proposition 4 *For any ρ_i^h and ρ_j^h, with $\rho_i^h > \rho_j^h$, a LBD optimal compensation scheme always exists and it assigns the first move to the worker j (leader) and the second move to the worker i (follower). The optimal compensation scheme is an asymmetric compensation scheme like the one described in Proposition 2*

Proof See the Appendix A.7.■

This result contains an implication particularly useful for *job design* if only limited budget are available to the employer. Since she knows the reciprocity concern of each worker, she will always find convenient to assign the second move to the worker with the higher ρ_i^h, obtaining the desired outcome at no cost.

1.5. Extension

In this section we present two extensions to the base model. In section 2.5.1 we analyze the case in which the principal has a budget constraint which is lower that the minimum payment which has to be offered off equilibrium in order to induce unpaid extra-effort in equilibrium. In subsection 2.5.2 we analyze the case in which the production technology exhibit negative externalities and therefore for the principal it may be not convenient to employ two workers if they are selfish.

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[17]Where the index "A" allows its distinction from the offered under symmetric information.

1.5.1. The optimal compensation scheme with budget constraint

In the previous sections we assumed the employer has a budget sufficient to induce unpaid extra-effort. Let B^F denote the feasible budget. Here we analyze the case where B^F is lower than the level required respectively in propositions 1 and 3.

Proposition 5

When $0 < B^F < \underline{B} = c(\frac{1}{\min\{\rho_i^h, \rho_j^h\}} + 1)$ $\left(< \underline{B}^A = \max\left\{\frac{c}{\rho_1^h}, c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h}\right\}\right)$, *the employer obtains* $2\gamma e$ *by paying to the employees a sum of compensations lower than the one paid to standard employees. Savings are increasing in the amount of the feasible budget.*

Proof. See the Appendix A.8.■

The result can be explained by the *substitutability* between reciprocity concerns and monetary incentives, i.e. material payments. When $B^F \in [\underline{B}; +\infty)$, reciprocity concerns and incentives are *perfect substitutes*. When $0 < B^F < \underline{B}$, reciprocity concerns and monetary incentives are *imperfect substitutes*. Therefore, in this second case, in order to obtain the highest output, the employer must pay in equilibrium a positive amount of compensations which is still lower than that required by standard workers. That is, even if extra-effort must be paid, some savings can be still achieved with respect to the benchmark case. This result highlights that, in our model, reciprocal workers are always preferred to standard workers.

1.5.2. Production Technology with Negative Externalities

In the previous sections we assumed a functional form which did not impose any *technological interdependencies* among the workers.[18] Now consider a production technology with some *negative*

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[18]According to Potter and Suetens (2009) a game is characterized by strategic complements (substitutes) if $\forall i, j$ and $i \neq j: \frac{\partial^2 u_i}{\partial a_i \partial a_j} > 0$ (< 0). Games characterized by strategic substitutability or strategic complementarity have externalities by their nature; this (at least locally) follows from the fact that: $\frac{\partial^2 u_i}{\partial a_i \partial a_j} > 0$ (< 0) implies: $\frac{\partial u_i}{\partial a_j} > 0$ (< 0).

externalities: $X^{'}(\gamma,\beta,a_{i,}a_{j})=\gamma(a_{i}+a_{j})-\beta(a_{i}a_{j})$ with $\gamma>\beta>0$, where β measures the level of negative externality form *joint extra-effort* exertion. It is also assumed that two workers undertaking extra-effort are more productive than one: $X(2\gamma e-\beta e^{2})>X(\gamma e)>0$ and furthermore assume that the employer maximizes her profits when only one standard worker undertakes extra-effort: $\Pi(\gamma,0_{i},e_{j})>\Pi(\gamma,e_{i},e_{j})>0$ for $i=1,2$ and $i\neq j$.

When both these assumptions hold, we obtain the following result:

Proposition 6 *Under a production technology characterized by negative externalities:* $X^{'}(\gamma,\beta,a_{i,}a_{j})$, *when* $\beta\in\left(\frac{\gamma e-c}{e^{2}};\frac{\gamma}{e}\right)$, *the employer will employ one worker, if he exhibits standard preferences, while she will form a team of two workers if they are reciprocal.*

When the employer creates a team of reciprocal workers, the joint extra-effort provision can be obtained at no cost by offering a compensation scheme as in Proposition 1 (3). Negative externalities may arise in productive settings where the workers' skills are partially substitutes rather than complements or in those situations where some form of congestion in production may result from the workers performing their job activity together. Our model complements the finding by Gould and Winter (2009), who analyze how the effort choices of selfish workers interact according to the production technology. In their model, a principal can employ one or two workers to carry out sequentially an individual task which contributes to the success of a project. When the production technology exhibits strategic complementarity, the task completion by one worker contributes more to the success of the entire project if also the other worker completes his/her task. By contrast, in the presence of strategic substitutability, the marginal contribution of a worker who succeeds in his/her task is higher when the other worker does not succeed. Therefore, Gould and Winter (2009) show that, depending on the value of the project, the principal may find it optimal to employ only one worker or both in the presence of strategic substitutability of the production technology. We show that workers' reciprocity is a reason for composing teams of two workers in situations where one standard worker would be employed. The intuition of this result is that, since reciprocity induces endogenous complementarity among the workers (Potter and Suetens, 2009), it mitigates the negative externalities imposed by the production technology. Therefore, by hiring reciprocal workers and by offering them a compensation scheme like those defined in propositions 1 and 3, the principal obtains the desired output at no monetary cost.

1.6. Vertical Reciprocity

The results presented in the previous sections are based on the assumption that vertical reciprocity does not affect workers' motivation. However, in many situations, this assumption may not hold[19]. Thus, in this section we allows the principal to choose between a relative and an individual compensation schemes and in this way we introduce vertical reciprocity beside horizontal fairness concerns in the workers' utility function.

In subsection 6.1 we define vertical reciprocity, then, in 6.2 we show that our main result defined in proposition 1 is robust to this extension as long as vertical and horizontal reciprocity concerns are additive. In subsection 6.3 we derive the conditions under which the principal still prefers to offer a relative compensation scheme when workers' vertical and horizontal reciprocity concerns are mutually exclusive. Finally, in subsection 6.4 we include in the employer utility function concerns about how workers perceive the compensation scheme offered. In this case, we derive the conditions under which the principal prefers to offer an individual compensation scheme inducing positive vertical reciprocity rather than a relative compensation scheme inducing negative reciprocity.

1.6.1. The vertical reciprocity Formulation

In order to introduce the vertical reciprocity we have to define both an actions set for the principal and a vertical reciprocity component in workers' utility function.

We assume that the principal can offer either a relative compensation scheme or an individual compensation scheme, as showed in figure 3. The individual compensation coincides with the one defined in section 4.1 for standard workers, where $w_i^S(e_i, a_j) = c$, if worker works extra, and $w_i^S(0, a_j) = 0$ otherwise, for $i, j = 1, 2$, with $j \neq i$. The relative compensation scheme coincides with the tournament defined in proposition 1, section 4.1, where each worker receives a compensation equal to B if he is the only one exerting extra-effort, and no compensation otherwise.

As shown previously, if the principal offers the relative compensation scheme, both workers, motivated by negative horizontal reciprocity, exert extra-effort to prevent a reward for the colleague. It follows that the principal will obtain the workers' extra-effort at no cost. On the contrary, when individual compensation is offered, each worker decides to work extra and since his compensation is

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[19]See for instance Fehr and Gächter (2002) for a survey.

independent from the colleague's choice, horizontal reciprocity is equal to zero.
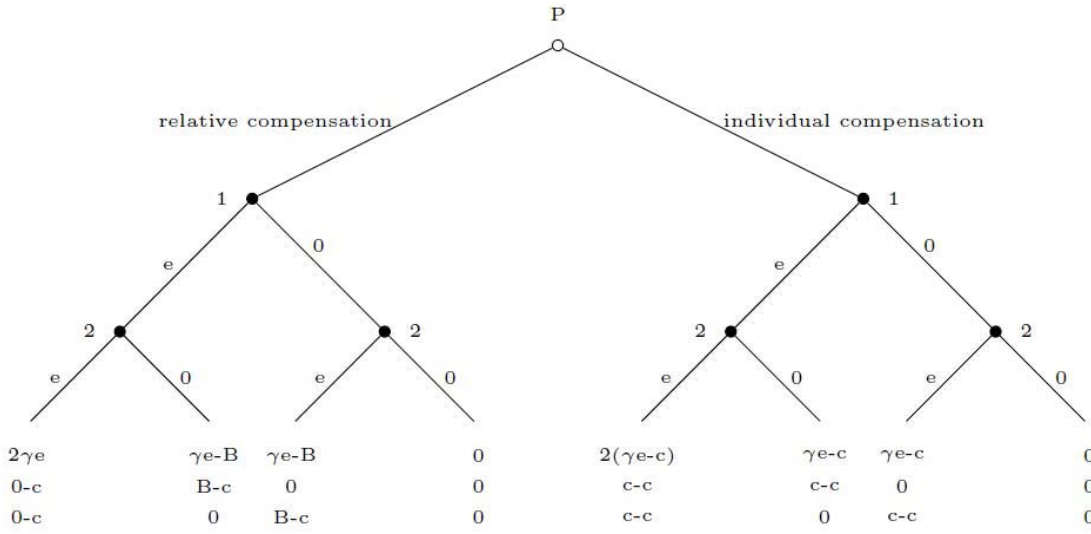
Figure 2.3. *Presence of Vertical and Horizontal Reciprocity*

The relevance of vertical reciprocity in worker i 's utility function is captured by the term $\rho_i^v \in [0,1]$. The *vertical reciprocity term* r_{i,σ_P} determines the magnitude of worker i 's reciprocity toward the principal. Denote by H_i and L_i respectively the highest and the lowest material payoff for A_i. Let σ_P and σ_P' be two strategies of the principal, with $\sigma_P \neq \sigma_P'$. Define $b_i^*(\sigma_j) = \sigma_i^*$ the player i 's best response to strategy σ_j chosen by player j such that $U_i\big(b_i^*(\sigma_j), b_j(\sigma_i)\big) \geq U_i(\sigma_j, \sigma_j) \ \forall \sigma_i \neq \sigma_i^*$, for any $i, j = 1, 2$ with $1 \neq 2$. Denote by M_i^* be the player i 's material payoff associated to the best response, such that, $M_{i,\sigma_P}^* \in U_i\big(b_i^*(\sigma_j), b_j^*(\sigma_i)\big)$, for any $i, j = 1, 2$ with $i \neq j$. The vertical reciprocity of A_i, given that the principal chooses the strategy σ_P, is defined as follows:

$$r_{i,\sigma_P} = \frac{M_{i,\sigma_P}^* - M_{i,\sigma_P'}^*}{H_i - L_i} \in [-1, +1] \tag{4.1}$$

The vertical reciprocity term in (4.1) is determined by comparing the material payoff that A_i obtains in the SPNE of each of the two subgames determined by the choice of the principal. As for horizontal reciprocity we normalize by $H_i - L_i$. Note that, when $r_{i,\sigma_P} > 0$ (< 0), then A_i will consider as fair (unfair) the principal's offer and consequently he will care positively (negatively) about the principal's profit.

In next two subsections we analyze separately the case in which horizontal and vertical reciprocity concerns are simultaneously present in the workers' utility function and the case in which they are mutually exclusive.

1.6.2. I case: additivity

In this subsection we assume that vertical and horizontal reciprocity concerns are additive, such that workers maximize the following utility function:

$$U_i(M_i, M_j, \Pi, \rho_i^h, \rho_i^v, r_i) = M_i + \rho_i^h r_{i,\sigma_j} M_j + \rho_i^v r_{i,\sigma_P} \Pi \tag{3.1}$$

The following proposition describes the optimal compensation scheme in this case:

Proposition 7. *Under symmetric information and $\rho_i^h, \rho_i^v > 0$ for $i = 1, 2$ the optimal compensation scheme is a tournament that induces workers' negative reciprocity both towards the colleague and the principal. Each worker receives a monetary compensation equal to B^{HV} if and only if he is the only one exerting extra-effort and no compensation otherwise, where $B^{HV} \geq \max\{\varphi_1, \varphi_2\}$ with $\varphi_i = \frac{c(1+\rho_i^h+\rho_i^v)+\sqrt[2]{c(1+\rho_i^h+\rho_i^v)^2+4\rho_i^h\rho_i^v c\gamma e}}{2\rho_i^h}$ for $i = 1, 2$. The principal obtains profits $2\gamma e$.*

Proof. See Appendix A9.∎

The optimal compensation scheme in proposition 7 induces a unique SPNE in dominant strategies. In equilibrium, the principal offers a tournament scheme and, if she can promise out of equilibrium a budget $B^{HV} = \max\{\varphi_1, \varphi_2\}$, she obtains the highest profits $2\gamma e$ by exploiting unpaid extra-effort. Under this compensation scheme, indeed, workers, motivated by negative reciprocity both toward the colleagues and the employer exert extra-effort without being compensated for it. Even in presence of negative vertical reciprocity the workers prefer to work extra rather than refusing it. This result recalls the compensation scheme defined in proposition 2, with the difference that $\underline{B}^{HV} > \underline{B}$ for any $\rho_i^v > 0$. In fact, when workers exhibit vertical reciprocity in addition to horizontal reciprocity, the minimum payment promised off equilibrium in order to induce unpaid extra-effort must compensate also the disutility related to the nasty offer made by the principal.

Notice that, if the principal would have offered the individual compensation scheme ,this would have induced positive vertical reciprocity by the workers. In particular, any individual compensation scheme assigning to the workers a positive compensation in case of extra-effort exertion induces positive vertical reciprocity. This follows the fact that such compensation scheme would be compared to the alternative relative compensation scheme which, in equilibrium, does not pay any monetary compensation. However, even if the principal could induce extra effort at a lower cost than the one required by standard workers (which is equal to c), her preferred choice remains the relative compensation scheme since it induces extra-effort by both workers at no cost.

1.6.3. II Case: Mutual Exclusivity

In this subsection we assume that vertical and horizontal reciprocity concerns are mutually exclusive. Indeed, experimental findings evidence, on one hand, that both envy between the workers and reciprocity towards the principal are relevant in determining tournaments' effectiveness, but, on the other hand, these two fairness concerns seems to be mutually exclusive, see Eisenkopf and Teyssier, 2009. A formulation in line with such findings is:

$$U_i(M_i, M_j, \Pi, \rho_i^h, \rho_i^v, r_i) = \begin{cases} M_i + \rho_i^h r_{i,\sigma_j} M_j & \text{if } \rho_i^h > \rho_i^v, \\ M_i + \rho_i^v r_{i,\sigma_P} \Pi & \text{if } \rho_i^v \geq \rho_i^h. \end{cases} \qquad (3.2)$$

Equation (3.2) indicates that the reciprocity concern which has the highest weight will prevail in the worker's utility function. Therefore we have two cases. If horizontal reciprocity concerns are stronger, $\rho_i^h > \rho_i^v$, we return to the situation described in section 4.1 and the optimal compensation scheme is defined in proposition 1.

If instead the reciprocity toward the principal is stronger, i.e. $\rho_i^v > \rho_i^h$, the optimal compensation scheme is described in Proposition 8 below.

Proposition 8. *Under symmetric information and* $\rho_i^v > \rho_i^h \geq 0$ *for* $i = 1,2$,

a) if $\gamma e \geq 2c(1 + \rho_1^v)$ *the optimal compensation scheme chosen by the principal is a tournament that induces negative vertical reciprocity. Each worker receives a monetary compensation equal to*

$B^V = \frac{c(1-\rho_i^v) + \sqrt{\left[-c(1-\rho_i^v)\right]^2 + 4c\gamma e}}{2}$ *if he exerts extra effort and no compensation otherwise. In equilibrium only the first*

mover exert extra-effort and the Principal obtains profits $\gamma e - B^V$;

b) if $\gamma e < 2c(1 + \rho_1^y)$ the optimal compensation scheme chosen by the principal is the individual payment scheme that induces positive vertical reciprocity. Each worker receives a monetary compensation equal to c if he exerts extra effort and no compensation otherwise. In equilibrium both workers exert extra-effort and the Principal obtains profits $2(\gamma e - c)$.

Proof. See Appendix A10.∎

In the case in which vertical reciprocity exceeds the horizontal one, the optimal compensation scheme is indicated in Figure 3. When the individual compensation scheme is offered, both workers exert extra-effort receiving a monetary compensation equal to c which is equivalent to the compensation required by standard workers to work. Therefore in this subgame's SPNE the Principal obtains $2(\gamma e - c)$ as profits[20].

When the relative compensation scheme is offered, the second mover judges as unfair the principal's offer, therefore to prevent his employer from gaining her highest profits; he prefers not to work extra. The difference in the second mover's behavior, here, is mainly explained by the irrelevance of the horizontal reciprocity concerns. In fact, the second mover does not suffer if the colleague receives high material payoff B^V and he prefers to let his colleague rather than the employer gain something.

The first mover, anticipating the shirking behavior of the colleague, experiences two contrasting forces. On one hand, working extra gives to him the highest monetary compensation B^V; on the other hand, choosing this action he suffers a loss of utility due to negative reciprocity. Since he is the only one working extra, indeed, he still allows the principal to obtain positive profits. The principal's profit in the SPNE of this subgame: $(\gamma e - B^V)$. Whether the tournament or the individual compensation scheme is going to be offered depends on the employer's profits. When $\gamma e \geq 2c(1 + \rho_1^y)$, the tournament maximizes the employer's profits, even if by offering a tournament only one worker

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[20]When the individual compensation scheme is offered it induces positive vertical reciprocity by the workers. This implies that under this compensation scheme workers are willing to exert extra effort for a monetary compensation equal to $k_i c$, where $k_i = \frac{(B^V + \rho_i^y \gamma e) - \sqrt{(B^V + \rho_i^y \gamma e)^2 - 4B^V c \rho_i^y}}{2\rho_i^y} < 1$. therefore, by employing reciprocal workers, the employer obtains extra effort by paying a sum of compensation lower than the one designed for standard agents.

In this case the results do not change qualitatively, although the complexity of the analysis increases noticeable.(The proofs are available upon request). Therefore, for a matter of simplicity, we consider the individual compensation scheme defined in Proposition 8.

exerts extra effort. In the other case, the most profitable compensation scheme is the individual compensation scheme which offers to the reciprocal agents the compensation scheme designed for standard workers

1.6.4. Principal with fairness concerns

In this subsection we include in the employer's profit function some concerns about the workers' perception of the compensation scheme offered. Indeed, in designing the compensation schemes for their workers, managers seem to care about how those compensation schemes are perceived (Agell and Lundborg, 1999). The utility function of the employer becomes:

$$U_p = \Pi(\gamma, a_i, a_j, r_{i,\sigma_P}, r_{j,\sigma_P}) + \delta \left[r_{i,\sigma_P} + r_{j,\sigma_P} \right] \qquad (1.1)$$

where $\delta \in [0,1]$ indicates the impact of fairness concern in the employer's utility function. The optimal compensation is described in Proposition 9 below.

Proposition 9. *Under symmetric information, if* $\rho_i^v, \rho_i^h \geq 0$

a) when vertical and horizontal reciprocity concerns are additive, if $\delta > \frac{B}{2}$ *the optimal compensation scheme is an individual payment scheme that induces positive vertical reciprocity;*
b) if vertical and horizontal reciprocity concerns are mutually exclusive, the individual compensation scheme is always optimal. In equilibrium both workers exert extra-effort and the employer obtains profits $2(\gamma e - c)$.

Proof See Appendix A11■

Therefore, as shown in the Appendix, introducing concerns about the workers' fairness perception in the employer utility function may determine that the individual compensation scheme becomes preferred to the relative one. This happens both in the case in which horizontal and vertical reciprocity are simultaneously present in the workers' utility functions and in the case in which they are mutually exclusive.

1.7. Discussion

In this paper we have presented a stylized model which uses horizontal reciprocity to provide a rationale for unpaid extra-effort. We have shown that when the employer has a budget sufficient to offer credible compensations out of equilibrium, she can always induce reciprocal workers to undertake productive extra-effort without fully compensating its cost. This result holds both under symmetric and asymmetric information. We have also identified the minimal budget required to support a scheme inducing unpaid extra-effort. In addition, we have shown that when the employer has a budget below that amount, even when positive monetary compensation is paid, some savings can still be made by exploiting the workers' reciprocity concerns. These results may have important implications for the ideal team composition. Indeed, the employer always prefers teams of reciprocal workers rather than teams with one standard and one reciprocal worker. Consequently, a "one standard/one reciprocal" team is always preferred to a team composed only of standard workers. We have developed an extension of the basic model which highlights the importance of horizontal reciprocity in the design of incentive systems characterized by a production technology imposing negative externalities among the workers. In this case, the employer will demand extra-effort from one worker if he is standard, while she will prefer to employ teams of two workers if they are reciprocal. These results are derived under the assumption that vertical reciprocity concerns do not play any role as large firms, where social distance between the employer and the workers are high, (Henning-Schmidt et al., 2010).

Given the relevance of vertical reciprocity in itself and the potential interactions between vertical and horizontal fairness, we extend the base model incorporating fairness towards the employer. Indeed, if the workers consider the relative compensation scheme as an unfair offer, it may be that the employer, anticipating the workers' negative reaction, may prefer to offer a different compensation scheme. Therefore we consider the case in which the employer can choose between a relative and an individual compensation schemes and we show that our main results are robust to this extension as long as vertical and horizontal reciprocity concerns are additive. When horizontal and vertical reciprocity are mutually exclusive, as evidenced in Eisenkopf and Teyssier (2009), we derive the conditions under which a profit maximizer employer would still prefer a tournament to an individual compensation scheme. Finally we analyze the case in which the employer exhibit fairness concerns about workers and we derive the conditions under which an individual compensation scheme inducing positive vertical reciprocity is preferred to a relative compensation scheme.

A final point deserves to be addressed. Unlike in our model, where the employer could determine how

to assign the order of moves to the employees, there is also the case where extra-effort is demanded from the workers simultaneously. In this case, employees face a simultaneous prisoner's dilemma, where the dominant strategy for each worker is to undertake extra-effort, so that the NE in pure strategies supports the outcome in which both workers undertake unpaid (underpaid) extra-effort. Even in a simultaneous move game, our main result holds: the employer will prefer to employ reciprocal workers, thus obtaining unpaid extra-effort. However, we chose a sequential game on the conviction that, at least in workplaces, it is actual behaviors more than beliefs and expectations that drive the reciprocal response between workers. Consistently, Cox et al.'s (2007) model defines reciprocity in sequential games where the fairness judgment is essentially based on actual behaviors, rather than, as in the psychological game theory literature, on beliefs and expectations.

Our simple model has emphasized that the optimal contract for reciprocal workers differs considerably from the optimal contract for standard workers. In particular, an employer dealing with workers motivated by reciprocity can always benefit from a relative performance contract which uses competition between employees to achieve the desired outcome. The higher the payment that the employer can promise out of equilibrium, the easier it will be to induce reciprocal workers to undertake underpaid or unpaid extra-effort. In real firms, our results may have interesting implications: if managers can credibly promise certain benefits to reciprocal workers out of equilibrium, they can exploit the employees' other-regarding preferences as sources of non-monetary incentives to enhance productivity. Professional services, research institutions, and the knowledge industry are organizational settings in which the workers' willingness to work hard to obtain career advancement or bonuses can be exploited by the employer inducing competition. In this regard, we may argue that, for real managers, our less striking result - underpaid rather than unpaid extra-effort - may be the most important one, because it represents a certain source of economic advantage for the organization which minimizes the possible drawback associated with unpaid extra-effort: namely, a negative attitude toward the employer.

References

1. Akerlof, G.A., 1982. Labor Contracts as Partial Gift Exchange. Quarterly Journal of Economics, 97(4), 543-569.

2. Alewell, D., Friedrich, C., Guth, W., (2007)."Fair Wages and Multiple Fairness Standards - A Lab Study of Co-Employment of Hired and Rented Hands, Schmalenbach Business Review, Vol. 59, January 2007.

3. Benabou, R., Tirole, J.,2006. Incentives and prosocial behavior. American Economic Review 96 (5), 1652--1678.

4. Carpenter, J., Matthews, P., 2009. What norms trigger punishment?. Experimental Economics, 12(3), 272-288.

5. Clark, A., (2005), What Makes a Good Job? Evidence from OECD Countries in Job Quality and Employer Behaviour, Bazen, S., Lucifora, C. and Salverda, W. (eds.), Palgrave, 2005, pp.11-30

6. Corneo, G.,Rob, R., 2003. Working in Public and Private Firms. Journal of Public Economics, 87, 1335-1352.

7. Cox, J. C., Friedman, D., Gjerstad., S., 2007. A tractable model of reciprocity and fairness. Games and Economic Behavior, 59, 17-45.

8. Delfgaauw, J., Dur, R., 2008. Incentives and Workers' Motivation in the Public Sector, Economic Journal, 118, 171-191.

9. Dur, R., Sol, J., 2010. Social interaction, co-worker altruism, and incentives. Games and Economic Behavior, Vol.69(2): 293-301 .

10. Eurostat, 2004. Statistics in Focus 10/2004: European Employment Increasing in Services and Especially in Knowledge Intensive Services.

11. Englmaier, F., Wambachb, A., 2010. "Optimal incentive contracts under inequity aversion", Games and Economic Behavior Vol.69(2):312-328

12. Eriksson, T., Villeval, M.C., 2008. Performance Pay, Sorting and Social Motivation, Journal of Economic Behavior and Organization, 68: 412-421.

13. Falk, A., Fehr, E., Fischbacher, U., 2003. On the nature of fair behavior. Economic Inquiry, 41(1),20-26.

14. Fehr, E., Fischbacher, U., 2002. Why Social Preferences Matter --- The Impact of Non-Selfish Motives on Competition, Cooperation and Incentives. Economic Journal, CXII (2002), C1-C33.

15. Fehr, E., Gächter, S., 2002. Fairness in the labor Market - A Survey of Experimental Results.

16. Fehr, E., Schmidt, K., 1999. A theory of fairness, competition, and cooperation. Quarterly Journal of Economics, 114,817-868.

17. Festinger, L., 1954. A Theory of Social Comparison Processes. Human Relations 7, 117--140.

18. Gächter, S., Nosenzo, D., Sefton M., 2010. The Impact of Social Comparisons on Reciprocity. CeDEx Discussion Paper No. 2010-10.

19. Gächter, S., and C. Thöni. 2009, Social Comparison and Performance: Experimental Evidence on the Fair Wage-Effort Hypothesis. CeDEx Discussion Paper 2009-23.

20. Gneezy, U., Rustichini, A., 2000. A Fine is a Price. Journal of Legal Studies, 29, 1-18.

21. Gould, E.D., Winter, E., 2009. Interactions between Workers and the Technology of Production: Evidence from Professional Baseball. The Review of Economics and Statistics, 91(1),188-200.

22. Hennig-Schmidt, H., Rockenbach, B., Sadrieh, A., 2010, In Search Of Workers' Real Effort Reciprocity-A Field and a Laboratory Experiment, Journal of the European Economic Association, Volume 8, Issue 4, 817-37.

23. Heywood, J., Jirjahn, U.,Tsertsvadze, G., (2005), "Getting along with colleagues- Does profit sharing help or hurt?", Kyklos, 58: 557-573.

24. Kahneman, D., Knetsch, J.K., Thaler, R.H.,1986. Fairness as a Constraint on Profit Seeking: Entitlements in the Market. American Economic Review, 76(4),728--41.

25. Kandel, E.,Lazear, E., 1992, Peer Pressure and Partnerships, Journal of Political Economy, 100, 801-13.

26. Landers, R. M., Rebitzer, J. B. and Taylor, L.J., (1996), Rat Race Redux: Adverse Selection in the Determination of Work Hours in Law Firms, Vol. 86, No. 3 (Jun., 1996), pp. 329-348

27. Mas, A., and E. Moretti, 2009, Peers at Work, American Economic Review 99(1), 112-145

28. Meyer, A., Wallette, M., 2005. "Absence of absenteeism and overtime work: signalling factors for temporary workers?", Working Paper Series No. 2005:15, Department of Economics, Lund University.

29. Milgrom, P. and Roberts R., 1992, Economics, Organization and Management, Prentice Hall, Englewood Cliffs, NJ (1992).

30. Mizunoya, T., 2001. "An International Comparison of Unpaid Overtime Work Among Industrialized Countries". Bulletin of the International Statistical Institute , 53rd Session Proceedings, Contributed Papers, Book 2, pp.159-160

31. Mossholder, K., Settoon, R., Henagan, S., 2005. A relational perspective on turnover: Examining structural, attitudinal, and behavioral predictors. Academic of Management. Journal, 48, 607-618.

32. Perugini, M., Gallucci, M., Presaghi, F., Ercolani, A., 2003. The Personal Norm of Reciprocity. European Journal of Personality, 17, 251-283.

33. Potters, J., Suetens, S., 2009. Cooperation in experimental games of strategic complements and substitutes. Review of Economic Studies, 76(3), 1125 - 1147.

34. Rabin, M.,1993. Incorporating Fairness into Game Theory. American Economic Review, LXXXIII, 1281-1320.

35. Rey-Biel, P., 2008. Inequity Aversion and Team Incentives. Scandinavian Journal of Economics, 108(2),297-320.

36. Rotemberg, J., 1994, Human relations in the workplace, J. Polit. Economy 102 (1994), pp. 684—717

37. Rotemberg, J., 2006. Altruism, Reciprocity and Cooperation in the Workplace. In: S. Kolm and Jean Mercier Ythier (Eds.), Handbook on the Economics of Giving, Reciprocity and Altruism, vol. 2, 1371- 1407.

38. Van Echtelt, P.,2007. Time-greedy employment relationships. Four studies on the time claims of post-Fordist work, PhD Dissertation, University of Groningen.

Appendix

A.1 Utility for Reciprocal workers

We define the utility function of reciprocal workers using a simplified formulation of reciprocity presented in Cox et al. (2007, p. 22). Let consider the formulation presented in their paper (eq.1):[21]

$$U_i(M_i, M_j, \theta_i(s,r)) = \begin{cases} \dfrac{M_i^\alpha + \theta_i(s,r)M_j^\alpha}{\alpha} & \text{if } \alpha \in (-\infty, 0) \cup (0,1], \\ (M_i M_j)^{\theta_i(s,r)} & \text{if } \alpha = 0, \end{cases}$$

where player j is the first mover and player i the second mover, U_j and U_i represent the utility function of each player and M_i and M_j are the material payoffs each player receives, α is the parameter of elasticity of substitution among the players' utility functions and $\theta(r,s)$ is the emotional state. Depending on the value of α preferences may be linear (if $\alpha = 1$) or strictly convex (if $\alpha < 1$). Cox et al. (2007) uses the concept of emotional state, θ, to characterize the attitude of player i toward player j. It represents the willingness to pay own payoff for other's payoff. The emotional state is assumed to be increasing both in the status, s, and in the level of reciprocity, r. The status is defined as the "generally recognized asymmetries in players' claims or obligations" (p. 23) while the reciprocity corresponds to the difference between the maximum payoff that player i can afford given the choice made by j and a reference payoff "neutral in some appropriate sense" (p. 23).

Our definition of reciprocity is a simplified version of the functional form proposed by Cox et al (2007). In particular, we impose $\alpha = 1$ and by assuming identical workers, we abstract from the status concern. Finally, for the sake of simplicity, we assume that the emotional state is a linear function of reciprocity, i.e. $\theta(r_i) = \rho_i \cdot r_{i,\sigma_j}$ where $\rho_i \in [0,1)$ represents the impact of reciprocity concern on worker i's utility function, and r_{i,σ_j} is the reciprocity term accounting for worker j's fairness.

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[21]The functional form is tested through experiments on a dictator game, a Stackelberg duopoly game, a mini-ultimatum game and an ultimatum game with both random and contest role assignment.

A.2 Proof of Proposition 1.

According to Proposition 1 the optimal compensation scheme is:

$$w_i(e_i,e_j) = w_i(0,e_j) = w_i(0,0) = 0; \quad w_i(e_i,0) = B, \text{ for } i,j \in \{1,2\} \text{ with } i \neq j \qquad (A.2.1)$$

Note that for A_1, strategies and actions coincide. On the contrary, for A_2 strategies are defined as follows: $\sigma_2^a = \{e,e\}; \ \sigma_2^b = \{e,0\}; \ \sigma_2^c = \{0,e\}$ and $\sigma_2^d = \{0,0\}$.

In equilibrium, reciprocity for A_1 and A_2 are respectively defined as:

$$r_{1,\sigma_2^a} = \frac{-w_1(e_1,0) + c}{w_1(e_1,0)} < 0$$

$$r_{2,e} = \frac{-w_2(0,e_2) + c}{w_2(0,e_2)} < 0$$

To induce both workers to exert extra-effort in equilibrium, the following incentive compatibility constraints (hereafter, ICCs) must hold:

$$w_1(e_1,e_2) - c + \rho_1^h r_{1,\sigma_2^a} w_2(e_1,e_2) \geq w_1(0,e_2) + \rho_{11,\sigma_2^a}^h w_2(0,e_2),$$

$$w_2(e_1,e_2) - c + \rho_2^h r_{2,e} w_1(e_1,e_2) \geq w_2(e_1,0) + \rho_{22,e}^h w_1(e_1,0). \qquad (A.2.2)$$

$$(A.2.3)$$

By substituting (A.2.1) respectively into (A.2.2) and (A.2.3) we obtain:

$$0 \geq c + \rho_1^h(-B + c),$$

$$0 \geq c + \rho_2^h(-B + c). \qquad (A.2.4)$$

$$(A.2.5)$$

Rearranging (A.2.4) and (A.2.5) yields

$$B \geq c\left(\frac{1}{\rho_i} + 1\right) \quad \text{for } i = 1,2, \qquad (A.2.6)$$

where B is the monetary compensation to be offered out of equilibrium to induce both workers to undertake unpaid extra-effort ($w_i(e_i,e_j) = 0$).

We proceed now proving that the compensation scheme in (A.2.1) induces a unique equilibrium in dominant strategies in which A_2 undertakes extra-effort both in the first and in the second subgame and A_1 undertakes extra-effort.

First we show that $\sigma_2^a = (e,e)$ is the dominant strategy for A_2. If A_1 chooses to undertake extra-effort, $a_1 = e_1$, the reciprocity for A_2 is given by:

$$r_{2,e_1} = \frac{\max\{(0-c),(0)\} - \max\{(B-c),0\}}{(B-c)-(0-c)} = -\frac{B-c}{B} < 0. \tag{A.2.7}$$

The utility A_2 gets if he undertakes extra-effort is: $-c + \rho_2^h r_{2,e_1}(-c)$, while the utility from not undertaking it is: $\rho_2^h r_{2,e_1}(B-c)$.

The extra-effort exertion is the optimal action for A_2 in first subgame if

$$-c + \rho_2^h r_{2,e_1}(-c) > \rho_2^h r_{2,e_1}(B-c). \tag{A.2.8}$$

By substituting (A.2.7) in to (A.2.8) and simplifying it, (A.2.8) yields $-c > \rho_2^h$ which always holds when (A.2.6) holds. Therefore we have proved that, when $B \geq c\left(\frac{1}{\rho_2^h}+1\right)$, in the first subgame the optimal action for A_2 is $a_2 = e_2$.

Suppose A_1 chooses $a_1 = 0$, the reciprocity for A_2 is given by:

$$r_{2,0} = \frac{\max\{(B-c),(0)\} - \max\{(0-c),0\}}{(B-c)-(0-c)} = \frac{B+c}{B} > 0. \tag{A.2.9}$$

The utility A_2 gets if he undertakes extra-effort is: $B-c$, while the utility from not undertaking it is 0. So, when $B > c$ the optimal action for A_2 in the second subgame is $a_2 = e_2$. When assumption (A.2.6) holds, $B > c$.

Consider A_1. we want to prove that $a_1 = e_1$ is the A_1 'dominant strategy.

If A_2 plays $\sigma = \sigma_2^a$ the reciprocity for A_1 is given by:

$$r_{1,\sigma_2^a} = \frac{\max\{(0-c),(0)\} - \max\{(B-c),0\}}{(B-c)-(0-c)} = -\frac{B-c}{B} < 0. \tag{A.2.10}$$

The utility A_1 gets if he undertakes extra-effort is $-c + \rho_1^h r_{1,\sigma_2^a}(-c)$, while the utility from not undertaking it is: $\rho_1^h r_{1,\sigma_2^a}(B-c)$. extra-effort exertion is the optimal action for A_1 if:

$$-c + \rho_2^h r_{2,e_1}(-c) > \rho_2^h r_{2,e_1}(B-c). \tag{A.2.11}$$

By substituting (A.2.10) in to (A.2.11) and simplifying it, (A.2.11) yields $-c > \rho_2^h(-B-c)$ which always holds when (A.2.6) holds. Therefore we have proved that, when $B \geq c\left(\frac{1}{\rho_1^h}+1\right)$ and given that A_2 plays

σ_2^a the optimal action for A_1 is $a_1 = e_1$.

Suppose now that A_2 chooses $\sigma_2^b = \{e, 0\}$, in this case A_1 's reciprocity is:

$$r_{1,\sigma_2^b} = \frac{\max\{(0-c),(0)\} - \max\{(B-c),0\}}{(B-c)-(0-c)} = -\frac{B-c}{B} < 0. \qquad (A.2.12)$$

The utility A_1 gets if he undertakes extra-effort is $-c + \rho_1^h r_{1,\sigma_2^b}(-c)$, while the utility from not undertaking it is: $\rho_1^h r_{1,\sigma_2^b}(B-c)$. Extra-effort exertion is the optimal action for A_1 if $-c + \rho_1^h r_{1,\sigma_2^b}(-c) > \rho_1^h r_{1,\sigma_2^b}(B-c)$ holds, which is exactly the case we have proved in (A.2.11).

Suppose A_2 chooses $\sigma_2^c = \{0, e\}$, in this case A_1 's reciprocity is:

$$r_{1,\sigma_2^c} = \frac{\max\{(B-c),(0)\} - \max\{(0-c),0\}}{(B-c)-(0-c)} = \frac{B+c}{B} > 0. \qquad (A.2.13)$$

The utility A_1 gets if he undertakes extra-effort is $B - c$, while the utility from not undertaking it is $\rho_1^h r_{1,\sigma_2^c}(B-c)$. To undertake extra-effort is always better than not undertaking it, since $B - c > \rho_1^h r_{1,\sigma_2^c}(B-c)$ always holds given that ρ_1^h and r_{1,σ_2^c} are both smaller than 1 by assumption.

Last, suppose A_2 chooses $\sigma_2^d = \{0, 0\}$, in case A_1 's reciprocity is:

$$r_{1,\sigma_2^d} = \frac{\max\{(B-c),(0)\} - \max\{(0-c),0\}}{(B-c)-(0-c)} = \frac{B+c}{B} > 0. \qquad (A.2.14)$$

The utility A_1 gets if he undertakes extra-effort is $B - c$, while the utility from not undertaking it is 0. To undertake extra-effort is always better than not undertaking if $B > c$, which is the case if (A.2.6) holds. Therefore $a_1 = e$ is A_1 's dominant strategy.

A.3   A compensation Scheme Inducing Positive Reciprocity

A.3.1 Symmetric Information Case

In this section we prove that a compensation inducing *positive* reciprocity for the exertion of extra-effort by both workers is more costly than the compensation scheme for standard workers. The total compensation paid to standard workers is $w_1^s(e_1,e_2)+w_2^s(e_2,e_1)=2c$. Now, consider A_1. When A_2 chooses strategy σ_2^a then the reciprocity of A_1 is:

$$r_{1,\sigma_2^a}=\frac{\max\{w_1(e_1,e_2)-c,w_1(0,e_2)\}-\max\{w_1(e_1,0)-c,w_1(0,0)\}}{H_1-L_1}.$$

(A.3.1.1)

Since $H_1-L_1>0$ then $r_{1,\sigma_2^a}>0$ if the numerator is positive. As $w_1(e_1,0)=w_1(0,0)=0$ then $\max\{w_1(e_1,0)-c,w_1(0,0)\}=w_1(0,0)=0$, and it suffices to show that $\max\{w_1(e_1,e_2)-c,w_1(0,e_2)\}>0$. This inequality holds in two cases:

(1a) if $\max\{w_1(e_1,e_2)-c,w_1(0,e_2)\}=w_1(e_1,e_2)-c>0$. This implies $w_1(e_1,e_2)>c$;

(2a) if $\max\{w_1(e_1,e_2)-c,w_1(0,e_2)\}=w_1(0,e_2)>0$. In this case, $r_{1,\sigma_2^a}=\frac{w_1(0,e_2)}{w_1(0,e_2)+c}>0$.

Similarly, reciprocity for A_2,

$$r_{2,e}=\frac{\max\{w_2(e_1,e_2)-c,w_2(e_1,0)\}-\max\{w_2(0,e_2)-c,w_2(0,0)\}}{H_2-L_2};$$

(A.3.1.2)

is positive if the numerator is positive.

As $w_2(0,e_2)=w_2(0,0)=0$, then $\max\{w_2(0,e_2)-c,w_2(0,0)\}=w_2(0,0)=0$. Therefore, $r_{2,e_1}>0$ if

(1b) if $\max\{w_2(e_1,e_2)-c,w_2(e_1,0)\}=w_2(e_1,e_2)-c>0$. This implies $w_2(e_1,e_2)>c$;

(2b) if $\max\{w_2(e_1,e_2)-c,w_2(e_1,0)\}=w_2(e_1,0)>0$. In this case, $r_{2,e}=\frac{w_2(e_1,0)}{w_2(e_1,0)+c}>0$.

By substituting these results respectively into A_1 and A_2 ICCs (A.2.2 and A.2.3) we obtain:

$$w_1(e_1,e_2)-c+\rho_1^h\frac{w_1(0,e_2)}{w_1(0,e_2)+c}w_2(e_1,e_2)\geq w_1(0,e_2)+\rho_1^h\frac{w_1(0,e_2)}{w_1(0,e_2)}w_2(0,e_2),$$

$$w_2(e_1,e_2)-c+\rho_2^h\frac{w_2(e_1,0)}{w_2(e_1,0)+c}w_1(e_1,e_2)\geq w_2(e_1,0)+\rho_2^h\frac{w_2(e_1,0)}{w_2(e_1}w_1(e_1$$

By combining 1a and 1b with 2a and 2b, we analyze the four possible cases where reciprocity is

positive for both workers.

- **Case 1a and 1b**. A compensation scheme where $w_1(e_1,e_2) > c$ and $w_2(e_1,e_2) > c$ are paid is necessarily more costly than the scheme proposed to standard workers which costs 2c.

- **Case 2a and 2b**. Rearranging the ICCs:

$$w_1(e_1,e_2) - c - w_1(0,e_2) + \rho_1^h \frac{w_1(0,e_2)}{w_1(0,e_2)+c} w_2(e_1,e_2) \geq 0,$$

$$w_2(e_1,e_2) - c - w_2(e_1,0) + \rho_2^h \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,e_2) \geq 0.$$

Note that both constraints are never satisfied for $w_1(e_1,e_2) < c$ and $w_2(e_1,e_2) < c$.

- **Case 1a and 2b** (case 2a and 1b is symmetric). We need to prove $w_1(e_1,e_2) + w_2(e_1,e_2) < 2c$.

Rearranging the ICC for A_2 we obtain $w_2(e_1,e_2) \geq w_2(e_1,0) + c - \rho_2^h \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,e_2)$. By subtracting this inequality from $w_1(e_1,e_2) + w_2(e_1,e_2) < 2c$ yields $w_1(e_1,e_2)(1 - \rho_2^h \frac{w_2(e_1,0)}{w_2(e_1,0)+c}) + w_2(e_1,0) - c < 0$. Since by (1a $w_1(e_1,e_2) > c$, this inequality is never satisfied and consequently any saving can be made under positive reciprocity.

A.3.2 Asymmetric Information

The same arguments used in section A.3.1 can be used to prove the result under asymmetric information. Note that in this case the reciprocity for worker 1 and 2 are respectively:

$$r_{1,\sigma_b} = \frac{\max\{w_1(2\gamma e) - c, w_1(0)\} - \max\{w_1(\gamma e) - c, w_1(\gamma e)\}}{H_1 - L_1},$$

$$\tag{A.3.2.1}$$

$$r_{2,e} = \frac{\max\{w_2(2\gamma e) - c, w_2(\gamma e)\} - \max\{w_2(\gamma e) - c, w_2(0)\}}{H_2 - L_2}.$$

$$\tag{A.3.2.2}$$

A.4 Standard Compensation Scheme for Reciprocal Workers

A.4.1 Symmetric Information

Consider the set of optimal compensation scheme for standard workers. Applying it to reciprocal workers yields:

$$w_1(e_1,e_2)= c; \; w_1(e_1,0) \in [0,B]; \; w_1(0,e_2) = 0; \; w_1(0,0) \in [0,B];$$
$$w_2(e_1,e_2)= c; \; w_2(e_1,0) = 0; \quad w_2(0,e_2) = c; \; w_2(0,0) = 0;$$

$$(A.4.1.1)$$

By substituting (A.4.1.1) in the ICC for A_1 (A.2.2) we can easily see that since A_1's choices do not affect the material payoff of A_2 then the *reciprocity component* in the utility function cancels since $w_2(e_1,e_2) = w_2(0,e_2)$. The ICC of A_1 coincides with the ICC of standard workers.

Now, consider now A_2 and substitute (A.4.1.1) in (A.2.3). It easy to see that when $w_1(e_1,0)=c$, as for A_1, the reciprocity component of the utility function is neutralized. Note that, when $w_1(e_1,0) \neq c$, substituting A.4.1.1 in the definition of reciprocity in (A.3.1.2) by assumption $r_{2,e} = 0$, (see section 2).

A.4.2 Asymmetric Information

Applying the set of optimal compensation schemes for standard worker to reciprocal worker:

$$w_1(2\gamma e) = c; w_1(\gamma e) \in [0, B]; \; w_1(0) = 0;$$
$$w_2(2\gamma e) = c; w_1(\gamma e) = w_1$$

$$(A.4.2.1)$$

by substituting this compensation scheme in the ICCs of each workers can be shown that each action worker does not affect the material payoff of the other, so for this reason, the reciprocity component in the utility function cancels out. In the frame of asymmetric information we are considering here, the multiplicity of optimal compensation schemes does not play any role, since, by calculating reciprocity of A_2 from (A.1.3.2) when (A.4.2.1) is offered, we obtain: $r_{2,e} = \frac{0}{c} = 0.$

A.5 Proof of Proposition 2

In this section we prove that the employer has the following rank over team composition: teams composed by two reciprocal workers are always preferred to teams composed by a standard worker and a reciprocal worker. Consistently, this latter team composition will be always preferred over team composed by two standard workers.

A team of standard workers produces $2\gamma e$ at a cost equal to $2c$. In subsection A.2 we show that a team of reciprocal workers produces the same output at zero cost for the employer. Let us consider the case of a team composed by a standard worker and a reciprocal worker.

Suppose $\rho_1^h = 0$, $\rho_2^h > 0$. To induce A_1 to undertake extra-effort a compensation scheme as the one described in subsection 3.1 ($w_1^S(e,a_2) = c$ and $w_1^S(0,a_2) = 0$) must be offered. On the contrary, A_2 chooses e_2 if paid according to (A.2.1). By substituting (A.2.1) in (A.2.3) we obtain:

$$w_2(e_1,e_2) \geq c - \rho_2^h \frac{B}{B+c}[w_1(e_1,0) - c].$$

Since the employer wants to maximize her profit, she will offer a $w_2(e_1,e_2)$ such that the ICC holds with equality. At this point:

- if $w_1(e_1,0) - c > 0$ then $w_2(e_1,e_2) < c$, namely, A_2 will undertake *under*-paid extra-effort. Hence by offering $w_1(e_1,0) = B > c$, the employer gets the output $2\gamma e$ by paying a sum of compensation lower than $2c$;

- if $\frac{B}{B+c}(B-c) \geq \frac{c}{\rho_2^h}$, A_2 will work *unpaid* extra-effort. In this case, the employer obtains $2\gamma e$ by paying a sum of compensations equal to c.

A.6 Proof of Proposition 3

According to Proposition 3 the optimal compensation scheme is:

$$\begin{aligned} w_1(2\gamma e) = w_1(0) = 0; \quad w_1(\gamma e) = B^A; \\ w_2(2\gamma e) = w_1(\gamma e) = 0; \quad w_1(0) = B^A \end{aligned} \tag{A.6.1}$$

The definitions of reciprocity for A_1 and A_2 in equilibrium are:

$$r_{1,\sigma_b} = \frac{-w_1(\gamma e)}{w_1(\gamma e) + c}, \quad r_{2,e} = \frac{-w_2(0)}{w_2(0) + c}.$$

In equilibrium, to induce both workers to undertake extra-effort, the following ICCs must hold:

$$w_1(2\gamma e) - c + \rho_1^h r_1 [w_2(2\gamma e) - c] \geq w_1(0) + \rho_{11}^h w_2(0),$$

(A.6.2)

$$w_2(2\gamma e) - c + \rho_2^h r_2 w_1(2\gamma e) \geq w_2(\gamma e) + \rho_2^h r_2 w_1(\gamma e).$$

(A.6.3)

By substituting (A.6.1) respectively into (A.6.2) and (A.6.3) we obtain:

$$0 \geq c + \rho_1^h \frac{-w_1(\gamma e)}{w_1(\gamma e) + c}[w_2$$

(A.6.4)

$$0 \geq c + \rho_2^h \frac{-w_2(0)}{w_2(0) + c} w_1(\gamma e)$$

(A.6.5)

Assume $w_1(\gamma e) = w_2(0) = B^A$. Rearranging (A.6.4) and (A.6.5) yields:

$$B^A \geq \frac{c}{\rho_1^h},$$

(A.6.6)

$$\frac{\rho_2^h}{c}\left(B^A\right)^2 - B^A \geq 0,$$

(A.6.7)

where $B^A \geq \frac{c}{\rho_1^h}$ is the monetary payment the employer must offer out of equilibrium in order to induce

A_1 to exert unpaid extra-effort $(w_1(2\gamma e) = 0)$.

Solving $\frac{\rho_2^h}{c}(B^A)^2 - B^A - c = 0$ yields

$$B_1^A, B_2^A = c \frac{[1 \pm (1 + 4\rho_2^h)^{\frac{1}{2}}]}{2\rho_2^h}.$$

(A.6.8)

Due to limited liability constraint the negative root makes no sense. Finally, the employer will offer out of equilibrium a level of B such that:

$$B^A \quad \max\left\{\frac{c}{\rho_1^h}, c\frac{1 + (1 + 4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h}\right\}.$$

(A.6.9)

Now we have to show that the compensation scheme in (A.6.1) induces a unique equilibrium which survives the iterated elimination of dominated strategies. In this equilibrium A_2 's dominant strategy is $\sigma_2^b = \{e, 0\}$ and A_1's best reply is $a_1 = e$.

Consider A_2. Suppose $a_1 = e$, then the reciprocity of A_2 is:

$$r_{2,e} = \frac{\max\{(0-c),(0)\} - \max\{(0-c), B^A\}}{(B^A} = -\frac{B^A}{B^A} < 0. \qquad \text{(A.6.10)}$$

The utility A_2 gets if he undertakes extra-effort is $-c + \rho_2^h r_{2,e}(-c)$, while the utility from not undertaking it is: $\rho_2^h r_{2,e}(B^A - c)$. extra-effort exertion is the optimal action for A_2 if

$$-c + \rho_2^h r_{2,e}(-c) > \rho_2^h r_{2,e}(B^A - c).$$
$$\text{(A.6.11)}$$

Substituting (A.6.10) in to (A.6.11) and simplifying it, (A.6.11) yields $-c(B^A + c) > -\rho_2^h(B^A)^2$ which holds when $B^A \quad \frac{1+(1+4\rho_2^h{}^{\frac{1}{2}}}{2\rho_2^h}$.

Suppose now $a_1 = 0$, then the reciprocity of A_2 is:

$$r_{2,0} = \frac{\max\{(0-c),(B^A)\} - \max\{(0-c),0\}}{(B^A) - (0-c)} = \frac{B^A}{B^A + c} > 0.$$
$$\text{(A.6.12)}$$

The utility A_2 gets if he undertakes extra-effort is $-c + \rho_{2_{2,0}}^h B^A$, while the utility from not undertaking it is B^A. Not undertaking extra-effort in the second subgame is the optimal action for A_2 if $B^A > -c + \rho_2^h r_{2,0}(B^A)$ holds, which is always the case, since $B^A > \rho_2^h r_{2,0} B^A$, given that $\rho_2^h < 1$ and $r_{2,0} < 1$. Therefore we have proved that σ_2^b is the A_2's dominant strategy.

Now we want to prove that $a_1 = e$ is A_1's best reply to σ_2^b. When A_2 chooses $\sigma = \sigma_2^b$ this is the reciprocity for A_1:

$$r_{1,\sigma_2^b} = \frac{\max\{(0-c),(0)\} - \max\{(B^A \quad {}^A\}}{(B^A} = -\frac{B^A}{B^A} < 0. \qquad \text{(A.6.14)}$$

The utility A_1 gets if he undertakes extra-effort is $-c + \rho_1^h r_{1,\sigma_2^b}(-c)$, while the utility from not undertaking it is: $\rho_1^h r_{1,\sigma_2^b} B^A$ Undertaking extra-effort is the optimal action for A_1 if

$-c + \rho_1^h r_{1,\sigma_2^b}(-c) > \rho_1^h r_{1,\sigma_2^b} B^A$ holds, which is the case when $B^A > \frac{c}{\rho_1^h}$.

A.7 Proof of Proposition 4

Here we want to prove that the LBD optimal compensation scheme assigns the second move to the worker that exhibit the highest ρ. Start from the (A.6.9). It contains two conditions that refer to the first and second mover: $B_1 \geq \frac{c}{\rho_1^h}$ and $B_2 \geq c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h}$, respectively, such that when

$$\forall \rho_1^h \neq \rho_2^h \text{ if } \rho_1^h(1+\rho_1^h) \quad \rho_2^h \Rightarrow c\frac{1+(1+4\rho_2^h)^{\frac{1}{2}}}{2\rho_2^h} > \frac{c}{\rho_1^h} \tag{A.7.1}$$

Suppose, without loss of generality, that $\rho_i^h > \rho_j^h$.

If the first move is assigned to i, $A_{1=i}$, then $\rho_{1=i}^h(1+\rho_{1=i}^h) > \rho_{2=j}^h$ and the binding condition is

$B_2 \geq c\frac{1+(1+4\rho_j^h)^{\frac{1}{2}}}{2\rho_j^h}$.

Suppose, on the contrary, that the second move is assigned to i, $A_{2=i}$. Two things may happen:

1) $\rho_{1=j}^h(1+\rho_{1=j}^h) < \rho_{2=i}^h$ such that $B_1 \geq \frac{c}{\rho_j^h}$ is the binding condition;

2) $\rho_{1=j}^h(1+\rho_{1=j}^h) \geq \rho_{2=i}^h$ such that $B_2^* \geq c\frac{1+(1+4\rho_i^h)^{\frac{1}{2}}}{2\rho_i^h}$ is the binding condition.

We know that $\forall \rho^h$, $B_2 > B_1$. namely:

$$c\frac{1+(1+4\rho^h)^{\frac{1}{2}}}{2\rho^h} > \frac{c}{\rho^h} \tag{A.7.2}$$

Consider case 1). By assigning the second move to worker i the binding condition would be $B_1 = \frac{c}{\rho_j^h}$, while by assigning to him the first move $B_2 = c\frac{1+(1+4\rho_j^h)^{\frac{1}{2}}}{2\rho_j^h}$. From (A.7.2) we see that $B_1 < B_2$.

Consider now case 2). By assigning the second move to worker i, the binding condition would be $B_2^* = c\frac{1+(1+4\rho_i^h)^{\frac{1}{2}}}{2\rho_i^h}$, while assigning to him the first move $B_2 = c\frac{1+(1+4\rho_j^h)^{\frac{1}{2}}}{2\rho_j^h}$. Again, from (A.7.2) we see that $B_2^* < B_2$. Therefore, we have proved that by assigning the second move to the worker with the highest ρ^h, the least budget-demanding optimal compensation scheme is offered.

A.8 Proof of Proposition 5

In this section we want to prove that, when $B > 0$ is lower than the level inducing workers to provide unpaid extra-effort, the employer could always obtain extra-effort by paying in equilibrium a total compensation lower than to $2c$.

A.8.1 Symmetric Information

Denote by B^F the feasible budget and assume $B^F < c\left(\frac{1}{\min\{\rho_i^h, \rho_j^h\}} + 1\right)$. In this case the ICCs for A_1 and A_2 are given by:

$$w_1(e_1, e_2) \geq c - \rho_1^h \frac{B^F + c}{B^F - w_1(e_1, e_2)} [B^F - w_2(e_1, e_2)],$$

(A.8.1.1)

$$w_2(e_1, e_2) \geq c - \rho_2^h \frac{B^F + c}{B^F - w_2(e_1, e_2)} [B^F - w_1(e_1 e_2)].$$

(A.8.1.2)

In order to maximizes her profit, the employer will set $w_1(e_1, e_2)$ and $w_2(e_1, e_2)$ such that the previous ICCs hold with equality. Let check if $w_1(e_1, e_2) + w_2(e_1, e_2) < 2c$. Rearranging it suffices to show

$$c - \rho_1^h \frac{B^F + c}{B^F - w_1(e_1, e_2)} [B^F - w_2(e_1, e_2)] + c - \rho_2^h \frac{B^F + c}{B^F - w_2(e_1, e_2)} [B^F - w_1(e_1 e_2)] < 2c,$$

$$-\rho_1^h \frac{B^F + c}{B^F - w_1(e_1, e_2)} [B^F - w_2(e_1, e_2)] - \rho_2^h \frac{B^F + c}{B^F - w_2(e_1, e_2)} [B^F - w_1(e_1 e_2)] < 0,$$

(A.8.1.3)

(A.8.1.4)

which are always verified since by assumption $w_1(e_1, e_2) + w_2(e_1, e_2) \leq B^F$.

A.8.2 Asymmetric Information

When $B^F < \frac{c}{\rho^h}$ and $B^F < \frac{c(1 + (1 + 4\rho^h)^{\frac{1}{2}})}{2\rho^h}$ the ICCs for A_1 and A_2 becomes respectively:

$$w_1(2\gamma e) \geq c - \rho_1^h \frac{B^F}{B^F + c - w_1(X^{2\gamma e})} [B^F + c - w_2(2\gamma e)],$$

(A.8.2.1)

$$w_2(2\gamma e) \geq c - \rho_2^h \frac{B^F}{B^F + c} [B^F - w_1(2\gamma e)].$$

(A.8.2.2)

The employer obtains $2\gamma e$ paying a sum of compensations lower than $2c$ if:

$$c - \rho_1 \frac{B^F}{B^F + c - w_1(2\gamma e)}\left[B^F + c - w_2(2\gamma e)\right] + c - \rho_2 \frac{B^F}{B^F + c}[B^F - w_1(2\gamma e)] < 2c$$

$$-\rho_1 \frac{B^F}{B^F + c - w_1(2\gamma e)}\left[B^F + c - w_2(2\gamma e)\right] - \rho_2 \frac{B^F}{B^F + c}[B^F - w_1(2\gamma e)] < 0$$

$$\text{(A.8.2.3) (A.8.2.4)}$$

Since $w_1(2\gamma e) + w_2(2\gamma e) \le B^F$ then the inequality are always verified.

A.9   Proof of Proposition 7

For the employer actions and strategies coincide. Denote with RC_P and IC_P respectively the employer's choice of the relative and the individual compensation scheme. According to Proposition 7 the optimal compensation scheme is:

$$w_i(e_i, e_j) = w_i(0, e_j) = w_i(0,0) = 0; \quad w_i(e_i, 0) = B^{HV} \quad \text{if } \sigma_P = RC_P;$$

$$w_i(e_i, a_j) = c; \quad w_i(0, a_j \quad \text{if } \sigma_P = IC_P, \text{ for } i, j \in \{1, 2\} \text{ with } i \neq j.$$

$$\text{(A.9.1)}$$

In the subgame identified by $\sigma_P = RC_P$, the SPNE is $(e_1, (e_2, e_2))$ and both workers obtain a material payoff equal to $-c$, therefore $M^*_{i, RC_P} = -c$ for $i, j = 1, 2$. As defined in Appendix 2, in this subgame the horizontal reciprocity for A_1 and A_2 are respectively: $r_{1, \sigma_2^a} = \frac{-B^{HV}}{B^{HV}}$ and $r_{2, e} = \frac{-B^{HV}}{B^{HV}}$. In the subgame identified by $\sigma_P = IC_P$, the SPNE is $(e_1, (e_2, e_2))$ and therefore $M^*_{i, RC_P} = 0$, while horizontal reciprocity is null.

First consider the worker .choices if $\sigma_P = RC_P$.

From eq. (4:1) we can calculate vertical reciprocity for both workers:

$$r_{1, RC_P} = -\frac{c}{B^{HV}};$$

$$r_{2, RC_P} = -\frac{c}{B^{HV}}.$$

To induce both workers to exert extra-effort the following ICCs must hold:

$$w_1(e_1,e_2)-c+\rho_1^h r_{1,\sigma_2^a}(w_2(e_1,e_2)-c)+\rho_1^v r_{1,RC_P}(2\gamma e)\geq$$
$$w_1(0,e_2)+\rho_1^h r_{1,\sigma_2^a}(w_2(0,e_2)-c)+\rho_1^v r_{1,RC_P}(\gamma e-w_2(0,e_2));$$
$$w_2(e_1,e_2)-c+\rho_2^h r_{2,e}w_1(e_1,e_2)+\rho_2^v r_{2,RC_P}(2\gamma e)\geq$$
$$w_2(e_1,0)+\rho_2^h r_{2,e}w_1(e_1,0)+\rho_2^v r_{2,RC_P}(\gamma e-w_1(e_1,0)).$$

Where the first inequality is (A.9.2) and the second one, (A.9.3). By substituting (A.9.1) respectively into (A.9.2) and (A.9.3) we obtain (A.9.4) an (A.9.5):

$$-c+\rho_1^h\frac{-B^{HV}+c}{B^{HV}}(-c)+\rho_1^v\frac{-c}{B^{HV}}(2\gamma e)\geq \rho_1^h\frac{-B^{HV}+c}{B^{HV}}(B^{HV}-c)+\rho_1^v\frac{-c}{B^{HV}}(\gamma e-B^{HV});$$

$$-c+\rho_2^h\frac{-B^{HV}+c}{B^{HV}}(-c)+\rho_2^v\frac{-c}{B^{HV}}(2\gamma e)\geq \rho_2^h\frac{-B^{HV}+c}{B^{HV}}(B^{HV}-c)+\rho_2^v\frac{-c}{B^{HV}}(\gamma e-B^{HV});$$

which rearranged become:

$$\rho_1^h\left(B^{HV}\right)^2-c(1+\rho_1^v+\rho_1^h)B^{HV}\quad \rho_1^v c\gamma e\geq 0,$$
$$\rho_2^h\left(B^{HV}\right)^2-c(1+\rho_2^v+\rho_2^h)B^{HV}\quad \rho_2^v c\gamma e\geq 0.$$

(A.9.6)

(A.9.7)

(A.9.6) and (A.9.7) yields

$$B^{HV}=\frac{c(1+\rho_i^v+\rho_i^h)\pm\sqrt[2]{c(1+\rho_i^v+\rho_i^h)^2+4\rho_i^v\rho_i^h c\gamma e}}{2\rho_i^h}\quad \text{for } i=1,2,$$

from which, by excluding the negative solution due to limited liability, we obtain:

$$B^{HV}\geq\frac{c(1+\rho_i^v+\rho_i^h)+\sqrt[2]{c(1+\rho_i^v+\rho_i^h)^2+4\rho_i^v\rho_i^h c\gamma e}}{2\rho_i^h}\quad \text{for } i=1,2,\qquad \text{(A.9.8)}$$

Where B^{HV} is the monetary compensation to be offered out of equilibrium to induce both workers to undertake unpaid extra-effort. The employer obtains $\Pi=2\gamma e$. Appendix 2 proves that exerting extra-effort is optimal for the workers once a relative compensation as the one described in (A.9.1) is offered.

Consider now the workers' choices when $\sigma_P=IC_P$.

From eq. (4.1) we can calculate vertical reciprocity:

$$r_{i,RC_P}=\frac{c}{B^{HV}}\quad \text{for } i=1,2.$$

To induce both workers to exert extra-effort the following ICCs (A.9.9) and (A.9.10) must hold:

$$w_1(e_1,e_2)-c+\rho_1^v r_{1,_{IC_P}}\left[2\gamma e-(w_1(e_1,e_2)+w_2(e_1,e_2))\right]\geq$$

$$w_1(0,e_2)+\rho_1^v r_{1,_{IC_P}}(\gamma e-w_2(0,e_2));$$

$$w_2(e_1,e_2)-c+\rho_2^v r_{2,_{IC_P}}\left[2\gamma e-(w_1(e_1,e_2)+w_2(e_1,e_2))\right]\geq$$

$$w_2(e_1,0)+\rho_2^v r_{2,_{IC_P}}(\gamma e-w_1(e_1,0));$$

by substituting (A.9.1) in (A.9.9) and in (A.9.10) we obtain:

$$\rho_i^v\,\frac{(\gamma e-c)c}{B^{HV}}\geq 0;\ \text{ for } i=1,2. \tag{A.9.11}$$

which are always satisfied.

The next step is to prove that exerting extra-effort is the optimal strategy for each worker. Consider A_2, first. (A.8.11) shows that, when A_1 does exert effort it is optimal for him to exert extra-effort as well. When A_1 does not exert extra-effort, for A_2 it is optimal to work extra if

$$w_2(0,e_2)-c+\rho_2^v r_{2,_{IC_P}}\left[\gamma e-w_2(e_1,e_2)\right]\geq w_2(0,0);$$

from which $\rho_2^v\,\frac{(\gamma e-c)c}{B^{HV}}\geq 0$, that holds. Therefore for A_2 exerting extra-effort is a dominant strategy. Consider now A_1. (A.9.9) shows that when A_2 exert effort it is dominant for A_2 to exert extra effort as well. In case A_2 does not exert effort, A_1, will prefer to work extra if:

$$w_1(e_1,0)-c+\rho_1^v r_{1,_{IC_P}}\left(\gamma e-(w_1(e_1,0))\right)\geq w_1(0,0);$$

from which $\rho_1^v\,\frac{(\gamma e-c)c}{B^{HV}}\geq 0$, that holds. For A_1 exerting effort is a dominant strategy.

Consider now the choice of the employer. If she offers the relative compensation scheme she earns $2\gamma e$, while if she offers the individual compensation scheme she earns $2(\gamma e-c)$. Therefore, the relative compensation scheme will be preferred to the individual one as long as this last requires a positive sum of compensations to be paid to the workers who exert extra effort.

A.10   Proof of Proposition 8

We only consider the case in which $\rho_i^v \geq \rho_i^h$ and therefore $U_i = M_i + \rho_i^v r_{i,\sigma_P} \Pi$. The proof for the case $\rho_i^h \geq \rho_i^v$ is contained in Appendix A.2.

According to Proposition 8 the optimal compensation scheme is described in (A.10.1):

$$w_i(e_i, e_j) = w_i(0, e_j) = w_i(0,0) = 0; \quad w_i(e_i, 0) = B^V, \quad \text{if } \gamma e \geq 2c(1 - \rho_i);$$

$$w_i(e_i, a_j) = c; \quad w_i(0, a_j) = 0, \quad \text{if } \gamma e < 2c(1 - \rho_i), \text{ for } i, j \in \{1, 2\} \text{ with } i \neq j.$$

a) The tournament is offered

Consider first A_2. When the tournament is offered, if A_1 exerts extra-effort, A_2 will exert extra effort if the following ICC holds (A.10.2):

$$w_2(e_1, e_2) - c + \rho_2^v r_{2,T_P}[2\gamma e - (w_1(e_1, e_2) + w_2(e_1, e_2))] \geq w_2(e_1, 0) + \rho_2^v r_{2,T_P}[\gamma e - w_1(e_1, 0)].$$

By substituting (A.10.1) in (A.10.2) we obtain:

$$-c + \rho_2^v r_{2,T_P} 2\gamma e \geq \rho_{22,T_P}^v (\gamma e - B^V). \tag{A.10.3}$$

From eq. (4.1), we can calculate vertical reciprocity in case the tournament is offered, which equals to $-\frac{c}{B^V}$. By substituting it, (A.10.3) becomes:

$$-c - \rho_2^v\left(\frac{c}{B^V}\right) 2\gamma e \geq \rho_2^v\left(\frac{c}{B^V}\right)(\gamma e - B^V), \tag{A.10.4}$$

which, rearranged, yields:

$$-c - \rho_2^v\left(\frac{c}{B^V}\right)(\gamma e + B^V) \geq 0. \tag{A.10.5}$$

(A.10.5) never holds $\forall$ $B^V \geq 0$. Therefore, when the tournament is offered, A_2 will not exert extra-effort if A_1 does.

Consider now A_1. Given that A_2 will not exert extra effort, A_1 will exert extra effort if the following ICC holds:

$$w_1(e_1, 0) - c + \rho_1^v r_{1,T_P}(\gamma e - w_{1\,1} \geq w_1(0,0) + \rho_{11,T_P}^v \tag{A.10.6}$$

By substituting (A.10.1) and the reciprocity in (A.10.6) we obtain

$$B^V - c + \rho_1^v \frac{-c}{B^V}(\gamma e - B^V) \geq 0;$$

(A.10.7)

rearranging (A.10.7), it becomes

$$B^{V2} - B^V c(1 - \rho_1^v) - \rho_1^v c\gamma e \geq 0.$$

(A.10.8)

Solving $B^{V2} - B^V c(1 - \rho_1^v) - \rho_1^v c\gamma e = 0$ yields

$$B_1^V, B_2^V = \frac{c(1 - \rho_1^v) \quad \sqrt{\left[-c(1 - \rho_1^v)\right]^2 - 4(-\rho_1^v c\gamma e)}}{2}.$$

(A.10.9)

Due to limited liability constraint the negative root makes no sense, therefore, the employer will offer a B^V such that:

$$B^V = \frac{c(1 - \rho_1^v) \quad \sqrt{\left[-c(1 - \rho_1^v)\right]^2 + 4\rho_1^v c\gamma e}}{2}.$$

(A.10.10)

Therefore, if the tournament is offered, A_1 will exert extra effort when A_1 refuses to do so.

Consider now the case in which A_1 does not exert effort. A_2 will exert effort if the following ICC holds:

$$w_2(0, e_2) - c + \rho_2^v r_{2, Tp} \left[\gamma e - w_2(0, e_2)\right] \geq 0.$$

(A.10.11)

By substituting (A.10.1) and the reciprocity in (A.10.11) we obtain

$$B^V - c + \rho_2^v \frac{-c}{B^V}(\gamma e - B^V \geq 0;$$

(A.10.12)

(A.10.12) is equivalent to (A.10.7). Therefore, we can say that, when A_1 does not exert effort. A_2 will exert effort if $B^V \geq \frac{c(1 - \rho_1^v) \sqrt{\left[-c(1 - \rho_1^v)\right]^2 + 4\rho_1^v c\gamma e}}{2}$.

Therefore, when the tournament is offered, the optimal strategy for the A_2 is $\{0, e\}$ and A_1's best reply is $a_1 = e$. The employer obtains profits equal to $\gamma e - B^V$

b) The individual compensation scheme is offered

The individual compensation scheme in (A.10.1) coincides with the optimal compensation scheme defined for standard agents in section 4.1. Notice that when this compensation scheme is offered, from

eq (4.1), vertical reciprocity is equal to $\frac{c}{B^V}$.

Both A_1 and A_1 will exert effort if the following ICC, in eq(A.10.13) holds:

$$w_i(e_i,a_j)-c+\rho_i^v r_{i,T_P}[2\gamma e-(w_i(e_i,a_j)+w_j(e_i,a_j))] \geq w_i(0,a_j)+\rho_i^v r_{i,T_P}[\gamma e-w_j(0,a_j)]$$

$$\text{for } i,j\in\{1,2\} \text{ with } i \neq j.$$

which by substituting (A.10.1) becomes:

$$c - c + \rho_i^v \frac{c}{B^V}(\gamma e - c) \geq 0 \quad \text{for } i, j \in \{1,2\} \text{ with } i \neq j; \tag{A.10.14}$$

which always holds.

Therefore, when the individual compensation scheme is offered, each agent exerts extra effort and the principal obtains profits equal to $2(\gamma e - c)$.

Choosing between tournament and individual compensation scheme.

Now, whether the employer will offer a tournament rather than an individual compensation scheme depends on which is the compensation scheme that maximizes her profits, as shown in the following condition:

$$\gamma e - B^V \geq 2(\gamma e - c). \tag{A.10.15}$$

When (A.10.15) holds, the employer will offer the tournament. By substituting in to (A.10.15) B^V from (A.10.12) we obtain:

$$\gamma e - \frac{c(1-\rho_1^v)\sqrt{[-c(1-\rho_1^v)]^2+4\rho_1^v c\gamma e}}{2} \geq 2(\gamma e - c); \tag{A.10.16}$$

which can be rewritten as:

$$3c - 2\gamma e + \rho_1^v \sqrt{[-c(1-\rho_1^v)]^2+4\rho_1^v c\gamma e}; \tag{A.10.17}$$

which can be reorganized as:

$$(3c - 2\gamma e + \rho_1^{v\,2} \geq [-c(1-\rho_1^v)]^2+4\rho_1^v c\gamma e. \tag{A.10.18}$$

After some calculations, (A.10.13) becomes:

$$2c(1+\rho_1^v) + \gamma e(\gamma e - c) \geq 0; \tag{A.10.19}$$

which holds if

$$\gamma e \geq 2c(1+\rho_1^v) \tag{A.10.20}$$

Therefore, when $\gamma e \geq 2c(1 + \rho_1^v)$ the employer will offer a tournament rather than an individual compensation scheme since it ensures the highest profits.

A.11   Proof of Proposition 9

Case 1: additivity of vertical and horizontal reciprocity.

The employer will prefer to offer the individual compensation scheme if

$$2(\gamma e - c) + \delta(r_{1,IR_P} + r_{2,IR_P}) \geq 2\gamma e + \delta(r_{1,T_P} + r_{2,T_P}); \tag{A.11.1}$$

which, considering that $r_{1,IR_P} = r_{2,IR_P} = \frac{c}{B}$ and $r_{1,T_P} = r_{2,T_P} = \frac{-c}{B}$ could be rearranged as

$$-2c + 4\delta \frac{c}{B} \geq 0; \tag{A.11.2}$$

from which we obtain

$$2\delta \geq B; \tag{A.11.3}$$

which, holds if

$$\delta \geq \frac{B}{2}. \tag{A.11.4}$$

Case 2: mutual exclusivity of vertical and horizontal reciprocity.

The employer will prefer to offer the individual compensation scheme if

$$2(\gamma e - c) + \delta(r_{1,IR_P} + r_{2,IR_P}) \geq \gamma e - B + \delta(r_{1,T_P} + r_{2,T_P}); \tag{A.11.5}$$

which, considering that $r_{1,IR_P} = r_{2,IR_P} = \frac{c}{B}$ and $r_{1,T_P} = r_{2,T_P} = \frac{-c}{B}$ could be rearranged as

$$B + \gamma e - 2c + 2\delta \frac{c}{B} \geq 2\delta\left(\frac{-c}{B}\right); \tag{A.11.6}$$

Which could be rearranged as

$$B + \gamma e + 4\delta \frac{c}{B} \geq 2c; \tag{A.11.7}$$

which is always satisfied, since, by assumption $B > c$ and $\gamma e > c$.

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Chapter 2

Incentive spillovers on voluntary cooperation[22]

CHAPTER PREVIEW: We investigate the impact of different incentives on simultaneous public good contributions in economically unrelated games. The results show that tournaments, but not simple piece rate schemes, reduce contributions by about 40%. However, the effect is brittle. The incentivized elicitation of beliefs eliminates the effect. It also vanishes immediately if the games are played sequentially rather than simultaneously. We conclude that designers of competitive incentive schemes must pay close attention to the framing of the scheme in order to avoid negative spillovers.

2.1. Introduction

There is a long-standing debate whether incentive schemes that focus on selfish interests of economic agents have an unintended impact on the same agents' behavior in other unrelated contexts. Extensive evidence from laboratory and field experiments supports the hypothesis that the effectiveness of incentive systems in organizations is strongly affected by individuals' intrinsic motivation and other regarding preferences (see, for example, the reviews in Deci, Koestner and Ryan 1999; Bénabou and Tirole 2003; Bénabou and Tirole 2006). However, such evidence comes mainly from situations in which the interaction between incentives and other regarding preferences takes place in a specific context and in isolation, while, in everyday life, individuals are simultaneously involved, often with different partners, in contexts which are different with respect to the types of incentives which are provided. Put differently, in reality people play "multiple games" with different people at the same time. We investigate whether there are spillovers of incentives provided in one game (e.g., the workplace) on voluntary cooperation in other spheres of daily life (e.g., community

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[22] Some section of this chapter will be part of the paper „Incentive Spillover on voluntary cooperation"jointly with Simon Gächter and Gerald Eisenkopf. This is a very preliminary and incomplete version. Please do not quote without permission.

work, civic life, neighborhood help etc). Does the provision of incentives at the workplace affect pro-social behavior outside the workplace?

For at least 40 years economists have considered that incentives may have unintentional side-effects. (Solow 1971; Titmuss 1971; Arrow 1972). Better access to relevant data and improved experimental designs allowed economists to investigate these effects in detail and add more insight into a topic that has been investigated by other social sciences for a while (e.g. Deci and Ryan 1985; Deci et al. 1999). Recent neurological evidence, for example, shows that economic incentives lead to lower activities in areas of the brain that are correlated with the expression of social preferences (Li, Xiao, Houser and Montague 2009). Bowles and Polania Reyes (2009) discuss the relevant literature, and in particular the impact of this evidence on public policy, in greater detail.

Most relevant studies have investigated how incentives affect voluntary cooperation within a given game, while they do not consider potential spillovers of incentives on cooperation with other people outside the incentivized game (Bowles 2008). In response, recent studies have investigated voluntary cooperation after, but not during, an exposure to different incentive schemes (e.g. Gächter, Kessler and Königstein 2008; Herrmann and Orzen 2008). These studies document a crowding out of voluntary cooperation, in particular after an exposure to incentive schemes characterized by high competition (e.g. tournaments or rent-seeking contests) but they do not investigate which specific feature of incentives determines this phenomenon.

Our experiment has two parts. In the main part we look at contributions of subjects in a public good game when these subjects are *simultaneously* exposed to a different incentive scheme in a parallel game. For each of the simultaneous games the group size is two and every subject has a different partner in each game. More specifically, in one game we always use a public good game while in the other we use either piece-rate payments, tournaments or another public good game. These incentive schemes differ with respect to the impact of one agent's choices on the payoff of the other group member. High choices imply a positive externality in the public good game, a negative one in the tournaments and no external effect at all in the piece rate scheme. There are no payoff spillovers between games, since each game is played with a different partner and with a separate endowment which cannot be transfer to the other game or across the 9 periods of play. The only link between the games is the player who simultaneously decides how to behave under an incentive scheme and how much to contribute to a public good shared with another player. Subjects received the payment for one randomly chosen period out of the nine.

Our experiments allow for several comparisons. Firstly, we compare voluntary public good contributions in which the incentives in the simultaneous games differ across the treatments.

Secondly we examine whether contributions to public goods differ *after* an exposure to different incentive schemes. Thirdly treatment variations take the impact of beliefs as well as risk, loss and inequity aversion into account.

Our results indicate that competitive incentive schemes (i.e. tournaments), but not simple piece rates, have a negative impact on simultaneous voluntary contributions to the public good. We can attribute this effect to the negative externality rather than the rather large spread in prizes that are both characteristic for tournament schemes.

This crowding out effect we observe on voluntary contribution is not just significant, it is also relatively large. Contributions decrease by almost 40% (or 70% of a standard deviation) when a tournament is simultaneously played. We exclude that the crowding out depends on a change in subjects' preferences for voluntary cooperation, since in an additional experiment, we show that being exposed to a competitive incentive scheme does not yield to a subsequent lower voluntary cooperation once the incentive scheme has expired.

We exclude that our result is driven by cognitive loads, i.e. the fact that playing simultaneously two games may be more demanding in cognitive terms than in playing just one, especially in their level of strategic interaction is different. Nevertheless the spillover effect we isolate in the main treatment is a rather brittle phenomenon because a simple change in the design (elicitation of beliefs) eliminates the crowding out.

2.2. Related Literature

In this section we discuss some studies related to our analysis. Two are the main branch of literature we contribute to.

The first one considers public good game, tournament and piece rate played in isolation. For each of this incentive scheme there is an extensive literature providing clear and robust evidences.

In finitely repeated public good games, subjects do contribute positive but decreasing amount to the public good, despite the NE in dominant strategies predicts null contribution, Fischbacher and Gächter (2009), [...]. In public good game as well as in team based-performance incentive schemes, given the payoffs' interdependence, a positive contribution by one player turns out to be a positive externality in the payoff function of another player. Similarly, if one player decreases her/his contribution this results in a negative externalities for the other players participating to the public good provision.

In tournaments subjects' behavior is more close to Nash equilibrium which predicts the highest possible effort exertion in equilibrium, see Harbing and Irlenbush 2003, 2008, […]. On the other hand, collusion would predict that agents do not participate in the tournament, letting the random mechanism of price assignment, to decide who is the winner. In finitely repeated tournaments higher frequencies of extreme behaviors are documented than in other games: some subjects, defined "max performers", choose to compete by exerting the highest effort in each round of the tournament, while others subjects choose to not participate, (Harbing and Irlenbush, 2008). In tournament, as in all incentives scheme based on relative performances' evaluation, an higher effort choice by one agents imposes a negative externality on the other agent's payoff.

Finally, we also consider a piece rate scheme, in which the optimal choices results from an individual decision making problem.

Bull et al (1987) in a between subjects study compare rank order tournaments and piece rates. They find that the mean of the effort levels chosen by subjects converge to their theoretical equilibrium levels, but they observe a larger variance in tournaments. They explain this partially with risk considerations which are relevant in tournament-like contexts while they are absent in piece rate.

The second strand of literature is more recent and it focuses of games played simultaneously. These studies aim documenting the existence and the economic relevance of behavioral spillovers across games, despite the theoretical prediction of independence between games played with different partners and separate endowments. The results from these studies are rich of implications for policymakers since they may deeply affect the design of incentives. However, the underlying mechanisms to explain and predict the causality of spillover effects are not sufficiently clear yet nor univocally supported.

For example, considering a Prisoner's dilemma, two coordination games and a selfish game, Bednar et al. (2010) provide evidences of behavioral spillovers when individuals simultaneously and repeatedly play two of these games in normal form, each with a different opponent. They find evidence for two different type of influences: individuals choose similar strategies in the two games and, if one of the two games is more complex, they are affected by decision-making strategies from the easier game.

Falk et al. (forthcoming) investigate social interaction effects when two identical coordination games with multiple equilibria or two public goods games are played simultaneously but with different partners. They find that mostly individual exhibit social interaction, namely, the contribution choices change as a function of his or her respective group members' behavior.

Savikhin and Sheremeta (2010) study individuals' behavior playing simultaneous in a competitive (lottery) and cooperative (public good) environments with two different and separate endowments but

with the same partner. This is the main difference with respect our design, in which each game is played with a different partner. Their result is complementary to ours, since we find that contributions to the public good is affected by the simultaneous participation to a competitive game, a tournament imposing negative externalities between agents.

Finally, Cason and Gangadharan (2010) investigate behavioral spillovers between a threshold public goods game and a competitive double auction market. They find that cooperation in public goods provision is less common when players simultaneously compete in the market.

2.3. Design and Procedures

The aim of the paper is to identify the existence and the impact of spillovers of incentive systems on individuals' willingness to cooperate in social dilemmas. In this section we present the design of the experiment and we give details on the experimental procedures. The central part of the experiment modifies the experimental design from Falk, Fischbacher and Gächter (forthcoming). A public good game similar to those described in Fischbacher, Gächter and Fehr (2001) and Fischbacher and Gächter (2010). A main difference to these studies is the group size and the Marginal Percapita Rate of Return in the public good game. In each session, the participants were randomly assigned to matching groups of four persons. Within such matching group, each participant is randomly selected to be member of 3 groups, such that he/she has a different partner in each group he participates during the whole experiment, as showed in Figure 1 for subject 1.

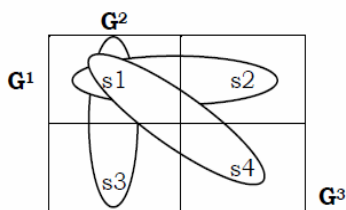

Figure 1. The matching group.
Note: numbers represent different subjects in the experiment.

In this example, in part 1 of the experiment subject 1 plays in group 3 with subject 4. Then, in part 2, she is simultaneously member of group 1 (together with subject 2) and group 2 (together with subject 3). Therefore, in each part of the experiment and in each game played, subject 1 has a different

partner in each group and this partner has not been encountered in the preceding game. We now explain the different parts in greater detail.

2.3.1. Part 1: The public good game

In part 1 subjects played a public good game as described in Fischbacher, Gächter and Fehr (2001, hereafter FGF, 2001), however with a group size of two instead of four. The marginal per capita return for one unit of contribution is of 0.75 instead than 0.4. The aim of this phase is to classify subjects according to their preferences for voluntary cooperation. One methodological benefit of this part is that it allows for an identification of differences in contribution patterns across sessions which are relevant in the context of rather large experiments with many different sessions and treatments. Having an endowment of 20 points[23] all subjects decided at first about an unconditional contribution towards a public good and they stated their beliefs about the unconditional contribution choice of the other group member. A correct belief was rewarded with 3 points, a one point deviation with 2 points, and a 2 points deviation was rewarded with 1 point. After that, subjects had to decide via the Strategy Method about their conditional contribution given any possible unconditional contribution of the other group member. The experimental software decided randomly whose unconditional contribution and whose conditional one was relevant for the final payment, as in FGF 2001. Any point contributed to the public good was transformed into 1.5 points of the public good and the (public) good produced in each group was shared equally between the two members. Any point not contributed was automatically paid out to the respective subject. In this part, subjects received no information about decisions made by their group member and their payments until the end of the entire experiment. In this game, selfish, rational participants choose a contribution of 0.

2.3.2. Part 2: The simultaneous decisions

In part 2, we distinguish between the three central treatments of our experiment. In each treatment, each subject was simultaneously member of two groups with different partners. With a separate endowment for each group, the subject had to take one decision for each group. In group 1, each subject faced an incentive system which differed in each treatment. In group 2, each subject had to decide how much to contribute voluntarily to a public good. Part 2 consisted of 9 periods, therefore each subjects had to take 9 decisions under a partners protocol in each group. To avoid endgame effects, the number of repetitions was not announced. At the beginning of each period subjects had to make their choices in each game on the same screen. The screen was divided in two vertical parts, called "group1" and "group 2" and contained an input box for each part. On the same screen, after each period, each subject also received information about (1) the choice of the partner in each group and about (2) their respective outcome in the previous periods and finally (3) her/his own outcome in both games in the previous period. At the end of the entire experiment, one of the nine periods was randomly selected and the subjects were paid for their outcomes in both games in that period. Therefore, in part 2, the two games are independent since they are played with different partners and with different endowments. The crucial link between the games is the player who simultaneously decides how to behave in each group.

For each decision in each treatment the subjects received an endowment of 20 points per period. As in part 1, any point not invested was paid out to the respective subject. The investment in each of the two simultaneous games came from two strictly separated endowments; therefore, it was not possible to transfer the endowment from one group to the other game or across the 9 periods.

In all four treatments, the decision in group 2, consisted in a voluntary, unconditional contribution of up to 20 points to a public good. The parameterization of the game was as in phase 1, therefore, any contributed point was transformed into 1.5 points of the public good which was shared equally between the two players in the group. Since subjects do not know the number of periods we do not make a point prediction for the equilibrium outcome of this public good game, indeed, our aim is to compare the subjects' behavior across treatments.

The decision in group 1 differed across the three treatments.

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[23] In the whole paper we will talk about points and not about money. The exchange rate during the experiment was 5 points= 1 Euro. One Euro was worth about 1.23 US-Dollar at the time of the experiment (June 2010).

a) **Treatment *VC&VC*.** In this treatment, the decision in group 1 consists of another voluntary unconditional contribution to the public good, identical to the one in group 2. This treatment with two parallel voluntary contribution decisions in two different groups provides a replication of the study by Falk, Fischbacher and Gächter (forthcoming), although we have a group size of two instead than four and a marginal per capita return of 0.75 for each contributed point, rather than of 0.6. In both games, a higher choice of one group member constitutes a *positive* externality on the other's payoff.

b) **Treatment *PR&VC*.** In this treatment, the decision in group 1 consists of variation of a piece-rate scheme (PR). In the piece-rate scheme could devote up to 20 points and the marginal return of an each additional point was positive but decreasing. The return for an investment choice *c* is given by the formula $2c - \frac{c(c-1)}{20}$. Subjects received information about the return for each possible choice through a table included in the instructions (See the Appendix). In this incentive scheme, the choice of one group member does not produce any externality on the return of the other's investment. Given the payment formula, in this scheme, a rational self interested agent will choose the optimal investment of 10 or 11 points in the piece rate.

c) **Treatment T&VC.** In this treatment, the decision in group 1 consist of a tournament (T), designed as in Harbing and Irlenbusch (2003)[24]. Subjects could devote up to 20 points to participate the tournament. The group member with the highest investment won a prize of 40 points, while the other receives no points. In case of equal investments, a random mechanism decided which group member received the 40 points. In the tournament, a higher choice of one group member constitutes a *negative* externality in the other's payoff. In the tournament, selfish, risk-neutral participants choose to invest all 20 points in the unique Nash equilibrium. Of course, the large spread in payments also imposes a risk on subjects. We address this problem in subsequent control treatment. We concluded all treatments with a questionnaire about the experiment.[…]

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[24] The tournament designed in Harbing and Irlenbusch (2003) can be considered as an extreme case of the tournament described in Lazear and Rosen (1981) in which the influence of the random component on subjects' effort choice is reduced to zero. We choose the Harbing and Irlenbush's design in order to isolate a competitive situation comparable to a piece rate scheme and to a public good game, in which the subjects' choices are not affected by any random component.

2.3.3. Experimental Procedures

Table 3.1 illustrates the number of participants in each treatment and the number of independent observations, (i.e. n° of matching groups) and the subjects' average earnings in each experimental treatment. We programmed the experiment with z-tree (Fischbacher, 2007) and conducted the experiment at the Lakelab, the laboratory for experimental economics at the University of Konstanz. Our 144 subjects were students at that university recruited via ORSEE (Greiner, 2004).

Table 3.1. Participants and treatments

Treatment	N° subjects	N° of independent obs. (matching groups of 4)	Average earnings for entire experiment (in €, st.dev in brackets)
VC&VC	48	12	15.56 (1.64)
PR&VC	40	10	15.38 (1.14)
T&VC	56	14	15.24 (3.83)

No persons participated in more than one treatment. None of them participated in a public good experiment before. The experiment lasted about 90 minutes

2.4. Results

We focus on the results from part 2 of the experiment in which the experimental treatments differ. We first present results at the aggregate level; then we analyze the behavior of subjects according to types' classification that we identify in part 1. More specifically we use the same classifications as FGF (2001), namely selfish, conditional cooperators, triangular cooperators and others.

2.4.1 Spillover effects on voluntary contributions

When subjects play simultaneously a tournament and a public good game (T&VC) we observe a crowing out of voluntary cooperation in the public good. This does not happen when two public goods are played simultaneously (VC&VC) or when a piece rate is played alongside a public good game (PR&VC). More specifically, voluntary contributions are significantly lower when subjects

simultaneously play a tournament alongside rather than another public good game or a piece rate incentive scheme.

Support for this result comes from Table 2 and Figures 2 and 3. For each treatment, Table 2 displays the mean and the standard deviations of the average voluntary contributions across periods in the decision taken in group 2, in part 2.

Table 2.2 Average voluntary contributions across the treatments

	VC&VC	T&VC	PR&VC
Average voluntary contribution	13.47	8.09	12.73
Standard deviation	6.83	7.62	6.87

The average contribution in VC&VC and PR&VC treatments is quite similar, but it is almost 40% lower in T&VC. Figure 2 presents the average voluntary contribution to public good in group 2 for each treatment and in each period. The figure reveals no systematic time trend in all treatments[25]. By comparing the average contribution in Figure 2 it can be noted that from the first period and along the whole length of phase 2, the contributions in treatment T&VC are lower than in the other two treatments from the first period.

We compare mean contributions with Mann-Whitney-tests. The matching groups of four compose one independent observation. All comparisons are based on average contributions of the four subjects in a matching group in a period. In the VC&VC and in PR&VC treatments, subjects contribute significantly more across all periods than in T&VC (for both comparisons: $p < 0.001$).

The contribution choices in treatments PR&VC and VC&VC do not differ in any single period. These results are confirmed if we compare the average contributions of a matching group across all periods and if we use a t-test.

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[25] The absence of the end game effect is due to the choice of not announcing the number of periods at the beginning of the experiment.
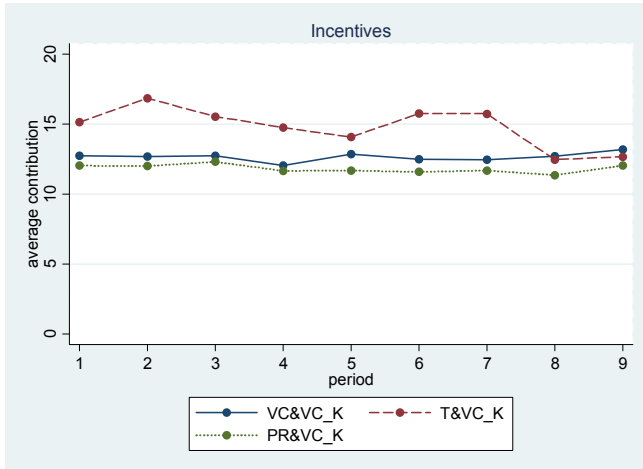
Figure 2.2a Average contributions in the incentive schemes (Dec1), by treatment
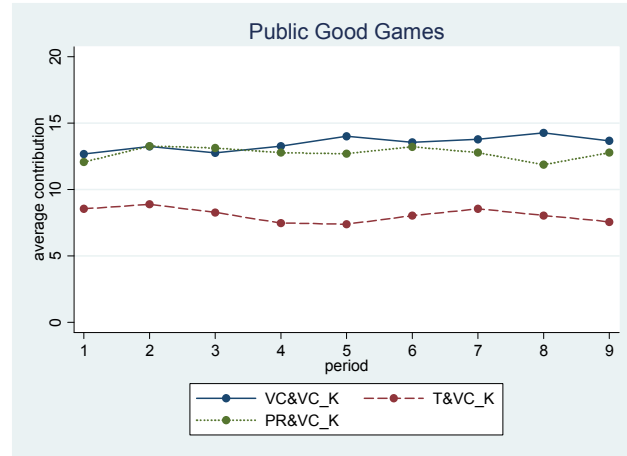
Figure 2.2b Average voluntary cooperation over periods in the public good game (Dec2), by treatment

Note also that the effect does not derive from differences in underlying cooperation preferences across the treatments. Appendix 1 shows that cooperation behavior in the public good game in the first part of the experiment does not differ significantly across the treatments.

In treatment VC&VC (Figure 3a) the most chosen combination of choices is (20, 20) with a relative frequency 0.28. It corresponds to the social optimum in both the public good games. The NE choices combination (0, 0) is chosen in 3.94% of the cases. If we look at the types classification obtained in phase 1, in the 88% of the cases, the NE choices combination is chosen by subjects classified as selfish, and never by subjects classified as conditional cooperators. The social optimal choices combination is taken by subjects classified as conditional cooperators 61.35% of the times.

In treatment T&VC, (figure 3b), the choice combination which is chosen with highest frequency (0.25) coincides with the NE predictions for both games (which are respectively 0 contribution in the public good and 20 in the tournament). The 13.49% of the choices are for the combination (20, 20) and if we look at the types' classification, in 50% of the cases are taken by subjects classified as conditional cooperators.

Finally in treatment PR&VC (Figure 3c) the choices combination which is mostly chosen is 20 in the PGG and 10 in the piece rate, with a relative frequency of 0.24, while the NE prediction would be 0 in the first game and between 10 and 11 in the piece rate. Surprisingly, in this treatment, subjects classified as selfish, chose to contribute their full endowment to the public good in 66.7% of the cases. This choice is taken by subjects classified as conditional cooperators only in 26% of cases.
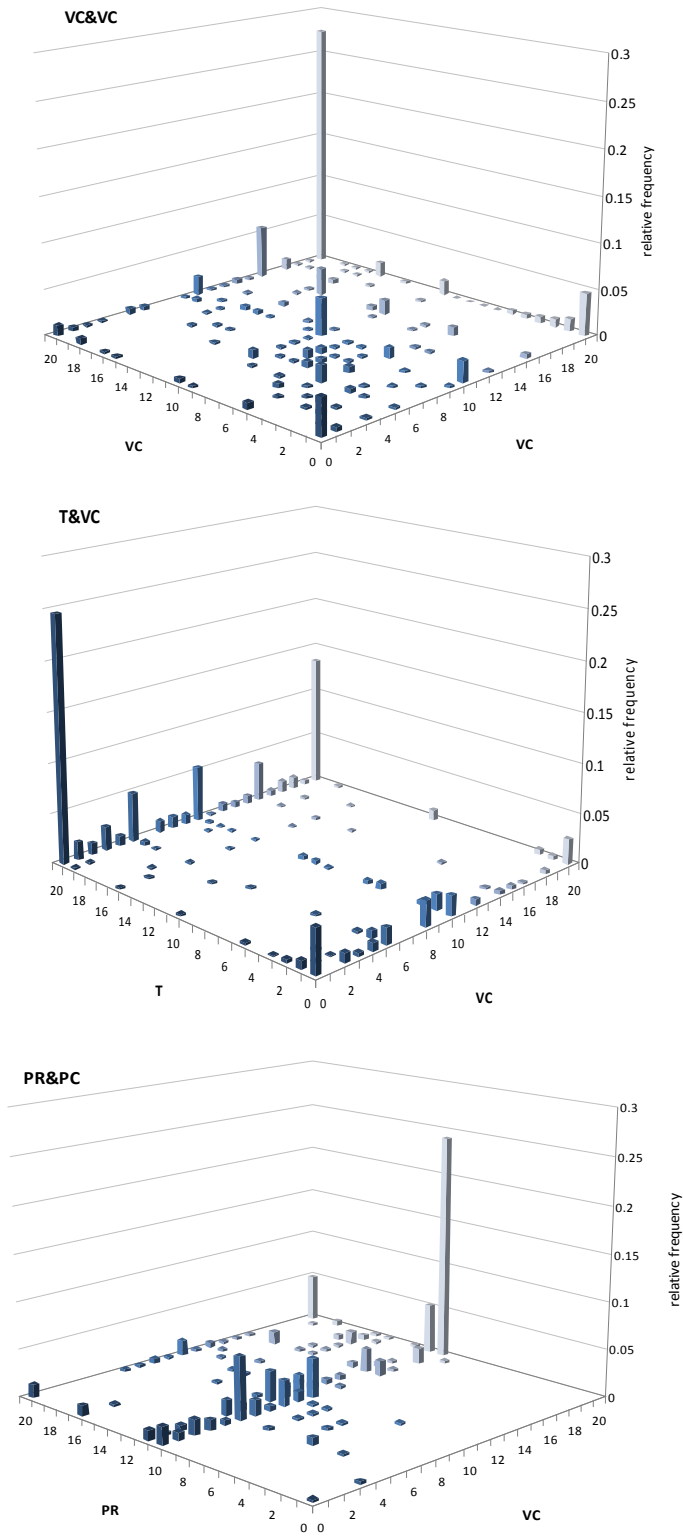
Figure 3. Contribution choices. a) treatment VC&VC; b) treatment T&VC and JT&VC; c) treatment PR&VC.'

The contribution by types

In this section we analyze the differences in contribution across treatment by using the types' classification of subjects according to their preferences profile in Phase 1.

Table 5 reports average voluntary cooperation and standard deviation for each type and for each treatment.

Table 5 Voluntary contribution by type

	VC&VC	T&VC	PR&VC
Selfish	11.38 (8.48)	13.85 (8.89)	6.44 (8.78)
Conditional Cooperators	14.06 (6.39)	12.37 (6.64)	8.48 (7.36)
Triangular contributors	-	7.78 (2.44)	10.89 (8.32)
Other	13.32 (6.36)	14.48 (8.86)	7.26 (7.25)

Across all treatments, do contribute significantly more across the nine periods than types classified as selfish: (t-test p-value 0.0014 and Mann Whitney test p-value 0.0273). This result is confirmed if we repeat the test for each single treatment (t-test p-value 0.0027and Mann Whitney test p-value 0.0164). No statistically significant differences are reported for first period contributions, neither across al treatments nor in each single treatment.

Figure 4a and 4b plot the types' average contribution to public good respectively between treatments and within treatments.

Figure 4a

Figure 4b

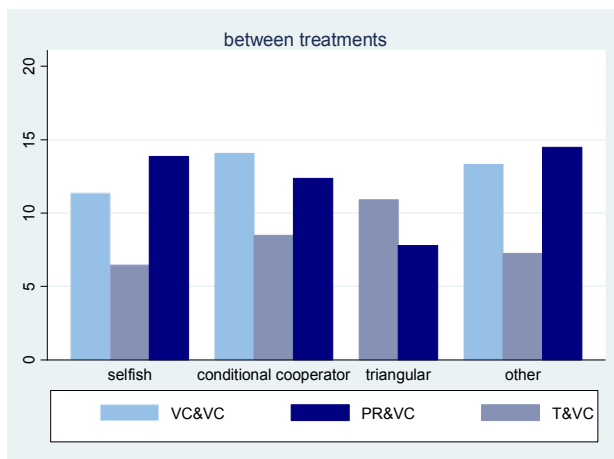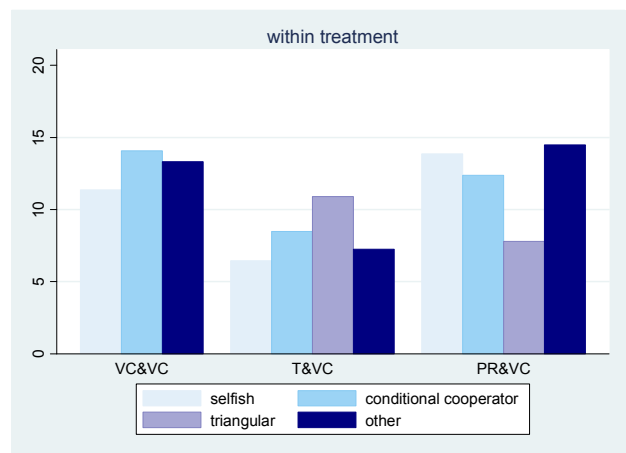From a first inspection, could be noted as in the treatment T&VC all types contribute in average less than in the other treatments, while not strong differences are evident in treatments VC&VC and PR&VC.

If we consider the average contributions made by each type *between* different treatments (figure 4a), it can be noted that that, for every type but triangular contributors[26], the contribution to public good in the treatment T&VC is significantly lower than in the other two treatments, where differences are small.

In particular, subject classified as *selfish*, in treatments VC&VC and PR&VC contribute in average respectively the 57% and 69% of their endowment across all nine periods and the difference in these average contributions is slightly statistically significant using a Mann-Whitney test: p-value 0.0884. In treatment T&VC the average contribution by selfish individuals falls to the 32% of their endowment which is significantly lower than in the other two treatments, Mann-Whitney test p-value 0.0005 for VC&VC vs T&VC and p-value 0.0000 for PR&VC vs T&VC.

Subjects classified as *conditional cooperators* contribute in average the 70% of their endowment in treatment VC&VC, slightly more than in treatment PR&VC, where they contribute in average the 62%, Mann-Whitney test p-value 0.0012. In treatment T&VC conditional cooperators' average contributions decrease significantly in both cases Mann-Whitney test p-values 0.000. This fall in contribution is confirmed if we repeat the Mann-Whitney tests in each period and it is significantly lower from the first period contribution.

Finally, subjects classified as "*other*[27]" do not differ in their average contribution to treatments VC&VC and PR&VC (t-test p-value 0.1452 and Mann-Whitney p-value 0.2978), while their contribution in T&VC is significantly lower (for both treatments both t-test and Mann-Whitney p-values 0.000).

All these result are confirmed by t-test where not differently specified.

Figure 4b considers contribution by types *within* each treatment. Interestingly, both in treatments VC&VC and T&VC, conditional cooperators do contribute significantly more than selfish but not more than subjects classified as other[28]. Interestingly, in treatment PR&VC, average contribution by conditional cooperators and selfish does not significantly differ, Mann-Whitney test, p-value 0.1447.

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[26] In our subject pool only 4 participants are classified as triangular contributors, therefore we dot consider this group in our analysis.

[27] In the group "other" we have in most part subjects which do contribute unconditionally to the pubic good and in minimal part subjects who do choose their contribution randomly.

[28] Treatment VC&VC: conditional cooperators contribute more than selfish, Mann-Whitney p-value 0.0250 but not significantly more than "other", Mann Whitney test p-value 0.2439. Treatment T&VC: conditional

2.5. Robustness Checks

The results in the previous section show a substantial negative spillover in the treatment with the tournament (T&VC). We now analyze robustness checks and potential explanations for this phenomenon. More specifically we look at the role of the prize allocation mechanism in tournaments, the impact of beliefs (and their elicitation) and at sequential treatments in which subjects play a public good after, not during their exposure to different incentive schemes. All reported experiments were conducted at the Lakelab according to the above mentioned procedures.

2.5.1. The role of the prize allocation mechanism in the tournament

There are three remaining different explanations why tournaments might crowd out voluntary contributions trough spillovers in simultaneous games. A high effort choice in tournaments imposes a negative externality on the other competitor, the prize's allocation mechanism imposes a risk on the participants and both phenomena may affect not only the choices in the tournament but also the voluntary contribution in the public good. In particular, the presence of negative externalities in the tournament may affect not only the beliefs about the other person's behavior in the tournament but also the beliefs about the other group member's contribution in the public good game. Moreover, those subjects classified as conditional cooperators may be more sensitive to such a change in beliefs. The presence of a risk associated to the prizes allocation mechanism, on the other hand, may induce subjects to invest more in the tournament but at the same time less in the public good game trying to control the strategic risk component in this last game obtaining a sure income at least from one of the two games.

In this section we analyze the role of risk imposed by the prize allocation mechanism then, in the next one, we explore the role of beliefs. We design an additional experiment as a variation of T&VC treatment to eliminate the risk in the tournament. Subjects again participate in multiple games. The decision in group 1 replicates the tournament in treatment T&VC with one difference: in case of equal investments by the group members, the price was shared equally. We therefore use the label ST&VC for this treatment, in which the 'S' stands for shared. Note that the negative externality between agents' choices is preserved and the sharing rule does not affect the behavioral predictions of full investment for selfish, risk-neutral participants (which expects an input of all 20 points in both T&VC

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cooperators contribute more than selfish but not more than subjects classifies as "other", Mann-Whitney test p-values respectively 0.0051 and 0.1026.

and ST&VC). The decision in group 2 remained a public good game, (VC). 56 subjects participated in this experiment. Table 3 displays the mean and the standard deviations of the average voluntary contributions across periods in the decision taken in group 2, in part 2.

Table 3 Average voluntary contributions across the treatments			
	VC&VC	**T&VC**	**ST&VC**
Average voluntary contribution	13.47	8.09	9.45
Standard deviation	6.83	7.62	7.24

The average contribution in ST&VC decreases by about 30% with respect to treatment VC&VC (and of about the 20% in treatment T&VC).

Figure 3 presents for each of these three treatments and in each period the average contribution to public good in group 2. No time trend is evident but for treatment ST&VC. Recall that in treatment T&VC the average contribution are significantly lower than in VC&VC in any period. On the other hand the contributions are not statistically different in treatments VC&VC and ST&VC between periods 1 and ($p > 0.11$). From period 5 onwards, subjects in the VC&VC do contribute significantly more than in ST&VC, $p < 0.0010$.
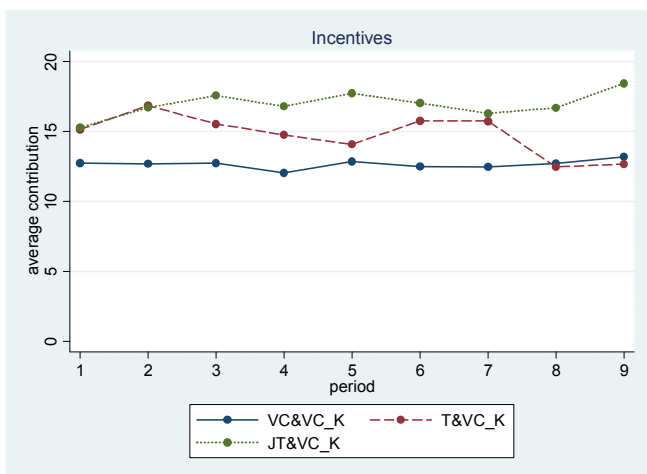

Figure 5a Average contributions in the incentive schemes (Dec1), by treatment
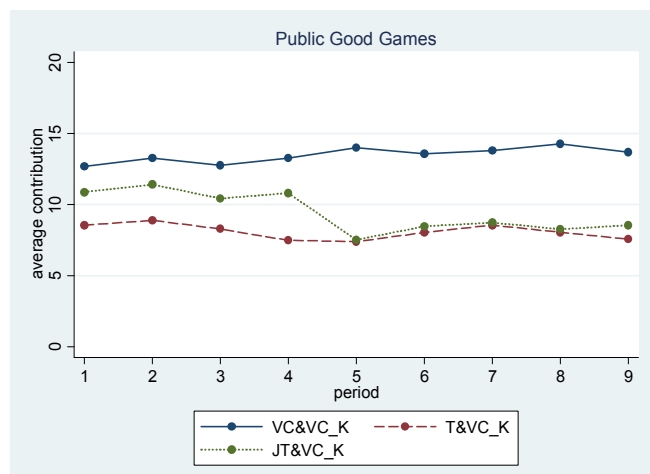
Figure 5b Average voluntary cooperation over periods in the public good game (Dec2), by treatment

Therefore we can exclude that the spillover effect documented in Section 2 is driven by the risk imposed on subjects by the prize allocation mechanism in the T&VC treatment, After some repetition,

indeed, the spillovers effect becomes again relevant and induces a significant crowding out in the subject's voluntary cooperation.

2.5.2. The role of beliefs

As mentioned in the previous subsection, when playing simultaneously a competitive incentive scheme, subjects may change their behavior in the voluntary contribution game because they believe that the other group member will do so as well. Therefore we repeated the simultaneous voluntary contribution and tournament treatments (VC&VC and T&VC, respectively) but elicited beliefs about the contribution of the other group member in each round. As in part 1 of the experiment, a correct belief was rewarded with 3 points, a one point deviation with 2 points, and a 2 points deviation was rewarded with 1 point. We tested 28 participants in the replication of the VC&VC treatments and 44 in the replication of the T&VC treatments. Moreover, we repeated with 20 subjects the T&VC treatment with not incentivized beliefs elicitation. The procedure of beliefs elicitation is not an innocuous change in the experiment design. Gächter and Renner (2010) show that incentivized beliefs increase the accuracy of beliefs but they also lead to an increase in contributions. Hence, this treatment variation implies a first robustness checks for our results.

Table 4 shows how the elicitation of beliefs does lower the contributions in the VC&VC treatment (Mann Whitney-test, p-value 0.0018) while it but it increases the voluntary cooperation in the T&VC treatment significantly. [Few observations]

Table 4 Average voluntary contributions across the treatments

	VC&VC		T&VC		
	Without beliefs	With incentivized beliefs	Without beliefs	With incentivized beliefs	With not incentivized
Average voluntary contribution	13.47	11.38	13.03	12.66	12.91
Standard deviation	4.57	4.14	4.73	4.83	4.75

If we consider treatment T&VC, average contribution does not change depending on the fact that beliefs are incentivized or not, (Mann Whitney-test, p-value 0.4937), [few observations]. However, if we compare treatment with and without beliefs elicitation, there is a significant higher contribution

when beliefs are elicited (Mann Whitney-test, p-value 0.4937) and this result is confirmed if we repeat the Mann Whitney-test in each single period.

Therefore, once beliefs are elicited, the result presented in section 2.1 is reversed; average contribution in T&VC(ib&b) is significantly higher than in VC&VC(ib), Mann Whitney-test, p-value 0.0291. Hence, a seemingly small procedural change eliminates the negative spillover of tournaments on voluntary contributions. Again this elimination does not occur because subjects in the different treatments have different underlying preferences for cooperation (see appendix 1).

Compare the behavior of types under beliefs elicitation.

In VC&VC and in T&VC we evidenced different tendencies in voluntary contribution depending on the fact that beliefs are elicited or not. In the first treatment voluntary contribution significantly decreases once beliefs are elicited. On the contrary, in treatment T&VC voluntary contribution significantly increases once beliefs are elicited. In what follows we restrict our analysis to the behavior of those subjects classified as selfish and as conditional cooperators in part 1 of the experiment, to analyze whether the beliefs elicitation procedures may differently affect different types of players.

Table 4a Average voluntary contributions by subjects classified as selfish across the treatments

	Selfish			
	VC&VC		T&VC	
	No beliefs	Beliefs elicitation	No beliefs	Beliefs elicitation
Average voluntary contribution	11.38	9.24	6.44	14.42
Standard deviation	8.48	8.19	8.78	6.96

In treatment VC&VC, subjects who are classifies as selfish do not change significantly their average contribution once beliefs are elicited, Mann Whitney-test, p-value 0.1249. The same result holds if we consider first period average contribution and the average contribution in each period. On the contrary, if we consider the average contribution of selfish in treatment T&VC, the beliefs elicitation double the average contribution, Mann Whitney-test, p-value 0.0000.

Table 4b Average voluntary contributions by subjects classified as conditional cooperators across the treatments

| | Conditional cooperators | | | |
| | VC&VC | | T&VC | |
	No beliefs	Beliefs elicitation	No beliefs	Beliefs elicitation
Average voluntary contribution	14.07	11.1	8.48	13.17
Standard deviation	6.31	6.80	7.36	7.72

For conditional cooperators, in T&VC beliefs elicitation significantly increases average contribution, (Mann Whitney-test, p-value 0.0000). In VC&VC, however, in presence of beliefs elicitation average contribution is significantly reduced, Mann Whitney-test, p-value 0.0020).[Here we have few observation, and moreover this hold just for cont2 and not for cont1]. Therefore, beliefs elicitation seems to have different effect on different types depending on the strategic context.

Notice how, in VC&VC both with and without beliefs elicitation, selfish types do contribute significantly less than subjects classifies ad conditional cooperators (Mann Whitney-test, p-value respectively 0.0662 and 0.0273). In T&VC the result is confirmed when we consider treatment without beliefs elicitation, (Mann Whitney-test, p-value 0.0051), while, once beliefs are elicited, the difference in average contribution between selfish and conditional cooperation is not statistically significant anymore (Mann Whitney-test, p-value 0.4209).

Regressions

In table 4c we use a regression analysis which attempts to explain the difference in voluntary cooperation given to beliefs elicitation in treatments VC&VC and T&VC.

We use three approaches, first a multilevel mixed random effects regression which allows for individual and group differences. Second a random effect Tobit estimation (controlled for individual difference) and third a Tobit model with standard errors clustered on matching groups. In all three models the dependent variable is the individual contribution in the public good.

The independent variables are "belief2" which identifies players' beliefs about the other's contribution to the PGG; othercont2 which identifies the others' contribution to the public good in group 2 in the previous period, tcont2 which identifies the subject's own contribution in group 2 in the previous period. Cont1 identifies the player's contribution in the incentive task, while othercont1 identifies the

others' contribution in the previous period in group 1 and belief1 indicates the subject' beliefs about other's contribution in group 1. Avsm1 identifies the average conditional contribution made in phase 1 of the experiment. T2 is a dummy which takes value 1 if the treatment is "T&VC". Period indicates the period index, and finally T2*beliefs is obtained as interaction between the dummies T2 and the beliefs (which takes value 1 if in the treatment beliefs elicitation was made and 0 otherwise).

In all three models the subjects' contribution to the public good game is significantly and positively affected by beliefs about other's contribution, own previous contribution and other's previous contribution as well as by the average conditional contribution and the interaction between treatment T&VC and beliefs. [more]

Table 4c			
	Model 1 Multilevel mixed random effect	Model 2 Random effect Tobit	Model 3 Tobit
Dependent variable	Cont2	Cont2	Cont2
belief2	.536762***	.9384376***	.9304655***
	(.0637316)	(.133253)	(.2381329)
tcont2	.2763119***	.7286883***	.7351508***
	(.0320183)	(.0632913)	(.1990724)
othercont2	.1643335***	. .328819***	.3345878***
	(.03434)	(.0677889)	(.0795474)
cont1	.0331915	.1076262*	.1080883
	(.0234801)	(.0465173)	(.0678616)
belief1	-.0719813*	-.0897484	-.0804825^
	(.0279146)	(.0550625)	(.0464139)
avsm1	.0118373	-.0451799	. -.0378758
	(.0551623)	(.0802565)	(.1226019)
T2	2.136474*	4.150149	3.83134
	(.9153117)	(1.689726)	(2.353741)
period	-.0203905	.167515	.1673467^
	(.060394)	(.1347158)	(.0969581)
T2 *belief2	-.1601816*	-.3876514**	-.3686564^
	(.0628199)	(.1309899)	(.2001949)
Constant	.7106131	-10.87421***	-11.13674
	(.958332)	(1.924841)	(2.475348)
σ(matchinggroups)	7.84e-08	–	
	(5.47e-07)		
σ (individual)	1.885745	.9937915	
	(.4611255)	(.6741523)	
σ(residual)	3.815803	7.281813***	7.304668
	(.1177782)	(.3122522)	(.9034295)
Observation	756	756	1056
Wald chi2(9)	802.01***	571.56***	
Standard errors in parenthesis; p***<0.001; p**<0.01; p*<0.05, p^<0.1			

2.5.3.   Differences between simultaneous and sequential decision making

In this last section we investigate the role of the subjects' preferences for voluntary cooperation in social dilemmas in order to assess whether the result in section 2 could be explained by a change in the preferences for cooperation as a consequence of having experienced a particular incentive scheme. To this extent, we conducted two treatments in which subjects participated in only one game in part two, either a voluntary cooperation game (the treatment label is *seqVC*) or a tournament (*seqT*) and then we measured their contribution to the public good game in a subsequent third part of the experiment. Subjects were informed that they would participate a third part consistent in repetition of public good game (as described in part 1) once they had completed the second part. Of course, the subject faced a different partner in each of the game played in the first part, the second part and the third part, which was identical to the first part but for the partner encountered. We opted for a repetition of part 1 rather than another voluntary cooperation game (without conditional contribution elicitation) because we wanted to investigate whether and how the incentive scheme altered on the cooperation profiles of the participants. It also guaranteed an immediate continuation of the experiment and ensured that subjects in both treatments had the same familiarity with the task they faced once the incentive scheme had expired.

We present the results in two steps. First we show that being exposed to a tournament rather than a public good game does not significantly affect the distribution of subjects' preferences profiles. Then we will show that both unconditional and conditional contributions do not change significantly different in both treatments between phase 1 and phase 3.

Table 5 shows that an exposure to a tournament rather than a voluntary contribution scheme does not significantly affect the cooperative behavior of subjects.

Table 5 Shares of types in phase 1 and phase 3 of the sequential experiment (all measures in percent)

	seqVC		seqT	
	Phase 1	**Phase 3**	**Phase1**	**Phase 3**
Selfish	14.58	22.92	13.64	22.73
Conditional cooperators	62.50	47.92	61.36	61.36
Triangular contributors	6.25	10.42	2.27	4.55
Other	16.67	18.75	22.73	11.36
N° subjects	48		44	

The table illustrates the type classification in phase 1 and in phase 3 in both sequential treatments.

The type's distribution across treatments is not statistically significant in phase 1 (χ^2 test, p-value 0.733). In phase 3 the type's distribution across treatment still does not differ, χ^2 test, p-value 0.453). Therefore, the exposure to a tournament or to a public good game does not affect the distribution of preferences profile across treatments.

However, even if we do not observe significant differences in the distribution of preferences' profiles between treatments, the classification of the types made in phase 1 is significantly different than the classification we obtain in phase 3, (χ^2 test, p-values 0.000). What we observe, is therefore, a change in the preference profiles which is not explained by the type of the incentive played in phase 2.

Similarly, the exposure to different incentive schemes does not affect the subjects' average conditional and unconditional contribution in phase 3 across treatment. Note that subjects' average unconditional contribution in phase 1 is slightly higher in treatment seqVC than in seqT. This difference disappear in phase 3, meaning that there is a significant decrease in the contribution within treatment seqVC from phase 1 to phase 3.

Table 6 contains mean of conditional contribution, unconditional contribution and beliefs in the PGG played in phase 1 and in phase 3 in both seqT and seqVC. In phase 1, the average unconditional contribution is slightly higher in treatment seqVC (t-test and Mann Whitney test both p-value 0.0422), while the average conditional contribution do not significantly differ between treatments (Mann Whitney test, p-values respectively 0.2026 and 0.1648). In phase 3 the average unconditional contribution does not significantly differ across treatments (Mann-Whitney test p-values respectively 0.3048 and 0.5156), the same result holds for the average conditional contribution, (Mann-Whitney test p-values respectively 0.9403 and 0.9031).

Table 6 Average contribution and variance of contribution to the PGG in phase 1 and in phase 3 of the sequential treatments.

	Unconditional Contribution		Conditional Contribution	
	Seq. VC	**Seq T**	**Seq. VC**	**Seq T**
Phase 1	10.38	7.98	7.43	6.05
Std. Dev.	6.21	6.96	4.94	4.46
Phase 3	8.63	7.75	5.92	5.81
Std. Dev.	5.86	6.99	4.57	4.81

The values for conditional contributions reflect average contributions of the subjects for each of the 21 potential choices of the respective other subject.

If we focus on the differences between phase 1 and phase 3, the average unconditional contribution do not differ significantly in the seqT (t-test and Wilcoxon test, p-values respectively 0.7852 and 0.774), while in treatment seqVC we observe a significant decrease in unconditional contribution (t-test, p-value 0.0180; Wilcoxon test, p-value 0.3585). We find a similar pattern for the average conditional contribution :(t-test and Wilcoxon test p-value 0.0147 and 0.0213 for treatment seqVC; while for treatment seqT t-test p-value 0.5848 and Wilcoxon test p-value 0.4743).

We perform a difference in differences analysis. The difference in differences estimator represents the difference between the pre-post, within-subjects differences of the treatment (seqT) and control groups (seqVC). Table 7 reports the Dif in Diff estimation on unconditional contribution estimated with an OLS regression (Models 1 and 3) and with a Tobit estimation, (Model 2 and 4). The variable Part is a dummy which takes value 1 if the observation refers to Part 3, and 0 otherwise. It captures the aggregate factors that would cause changes in the dependent variable even in the absence of any treatment in part 2. The dummy seqT=1 if the observation is from the treatment seqT and 0 if it rather refers to treatment seqVC (our control group). The coefficient of this dummy captures possible differences between the treatment and control groups. Finally, the difference in differences coefficient refers to the variable part*seqT", which is obtained as the interaction from the two previous dummies. This variable is equal to one for those observations in the treatment group (i.e. seqT) and in part 3, and it takes value 0 otherwise.

In models (3) and (4) we introduce some controls: "beliefs" takes value between 0 and 20 and it indicates each subject's beliefs about the unconditional contribution of the group member. Then we also include the average conditional contribution of subjects which is used to classify subjects into types.

The difference in differences coefficient is not significant in any model. In both models, the coefficient of the dummy Part is significant and negative, meaning that in phase 3 subjects do contribute less, however, since the coefficient seqT is always not significant, it means that the lower contribution is not related to a specific incentive scheme. In Models 3 and 4 beliefs have a positive and significant effect on subject's contribution, as well as the average conditional contribution.

Table 10. Difference in Differences estimations

	Model (1)	Model (2)	Model (3)	Model (4)
Dependent variable	Unconditional contribution			
Independent variables	OLS	TOBIT	OLS	TOBIT
	−1.75**	−2.981665**	−1.184213*	−2.086846*
Part	.604454	1.019248	.5450542	.8493113
	−2.397727^	−2.982133	−1.024438	−.9689811
seqT	1.368431	1.884772	.8198534	1.054448
Part*seqT	1.522727	2.248646	1.049301	1.592164
	1.175384	1.792821	1.201387	1.69137
Beliefu			.6737686***	.9116874***
	−	−	.0759145	.115728
Average conditional contribution			.3759485 .	.5494477***
	−	−	0797925	.1106602
Constant	10.375***	10.8094***	1.15299	−1.963154
	.7505134	1.044453	.815292	1.352908
N° obs	184	184	184	184
N° matching groups	23	23	23	23
Log pseudo likelihood	F(3,22)	−513.86352		−437.18613
F	3.60*	(3,181) 3.92**	F(5,22) 64.33***	(5,179) 23.54***
R2	0.0253	−	0.6021	−
Left censored	−	34	−	34
Uncensored	−	123	−	123
Right censored	−	27	−	27

*** denotes significance at 0.1% level; ** denotes significance at 5% level, ^ denotes significance at 10% level. Robust Std. Err. Clustered on 23 matching groups are reported in parenthesis

Interestingly, these results are in contrast to those obtained in Herrmann and Orzen (2008) who found a crowding out effect of anterior exposure to tournaments but also larger instability of behavior in prisoner's dilemma games.

Finally following Savikhin and Sheremeta (2010), we try to measure the degree of strategic uncertainty in the games we use to assess whether a greater cognitive load in simultaneous treatments may explain our result in section 3. Indeed, Savikhin and Sheremeta (2010) and Cason (2009) posit that the *cognitive load* effect should cause the subject to use strategies from the simplest game to motivate her behavior in the more difficult game. Therefore, as in Savikhin and Sheremeta (2010) we measure the degree of volatility in individual decision-making by computing the absolute difference between the decisions made in period *t* and period *t*-1.

Differently than in Savikhin and Sheremeta (2010)[29] we find that both in seqVC and in seqT the average volatility in choices is higher than in the correspondent simultaneous treatments, VC&VC and T&VC. In particular volatility in seqVC is equal to 2.97 vs 2.25 in VC&VC, significant using a t-test , p-value 0.0078 and a Mann Whitney test, p-value 0.000; while in seqT volatility is equal to to 6.97 vs 4.43 in T&VC, significant using a t-test and a Mann Whitney test, both p-value 0.000. The results are confirmed if we consider simultaneous treatments with beliefs elicitation VC&VC(b) and T&VC(b).

2.6. Discussion

We report results from experiments which investigate the impact of different incentives on voluntary public good contributions. The results show that competitive incentives (i.e. tournaments) crowd out such voluntary cooperation. We attribute this effect in parts to the implicit negative externalities in tournaments because an exposure to piece-rate incentives does not yield the same results while changes in the risk structure of tournament payments yield similar results. The effect is also rather strong as tournaments induce an average decline of 30% to 40% in voluntary contributions. The effect is strong but also brittle. The mere elicitation of incentivized beliefs along the standard treatments reverses the decline in cooperation. We are currently investigating if this result also holds for non-incentivized belief elicitation. The effect also vanishes if subjects play a public good game after rather than during their exposure towards different incentives.

We draw two conclusions from these results. The first one is methodological and concerns framing. Our experiment is basically a public good experiment in different circumstances which should have no impact on contributions. We observe differences in contributions across treatments (i.e. a crowding out of voluntary cooperation) but a seemingly small change in the experimental design eliminates these differences. Future research on crowding out should take this into account.

Our second conclusion is about the optimal use of incentives. Simple piece-rate schemes do not produce negative (or positive) spillovers. Competitive incentives can have a strongly negative impact on public good contributions but this impact is brittle and does not last. Hence, competitive incentive

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[29] They find that in contest-VCM treatment, the average volatility of bids in the contest is higher than the average volatility of contributions in the VCM (14.8 versus 12.2). They use this result to make the hypothesis that the VCM game should have a stronger *behavioral spillover* effect onto the contest.

schemes do not necessarily lead to negative spillovers. Simple variations can avoid them but it is important to check which variation is helpful and which not.

References

1   Arrow, K. J. (1972). "Gifts and exchanges." Philosophy & Public Affairs 1(4): 343-62.

2   Bednar, J., Chen, Y.,Liu, T.X., Page, S., (2010), Behavioral Spillovers and Cognitive Load in Multiple Games: An Experimental Study,

3   Benabou, R. and J. Tirole (2003). "Intrinsic and extrinsic motivation." Review of Economic Studies 70(3): 489-520.

4   Bénabou, R. and J. Tirole (2006). "Incentives and prosocial behavior." The American Economic Review 96(5): 1652-78.

5   Bowles, S. (2008). "Policies designed for self-interested citizens may undermine" The moral sentiments": Evidence from economic experiments." Science 320(5883): 1605.

6   Bowles, S. and S. Polania Reyes (2009). Economic incentives and social preferences: A preference-based lucas critique of public policy, CESifo, Center for Economic Studies & Ifo Institute for economic research.

7   Deci, E. L., R. Koestner and R. M. Ryan (1999). "A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation." Psychological bulletin 125: 627-68.

8   Deci, E. L. and R. M. Ryan (1985). Intrinisc motivation and self-determination in human behavior. New York, Plenum Press.

9   Falk, A., U. Fischbacher and S. Gaechter (forthcoming). "Living in two neighborhoods-social interaction effects in the lab." Economic Inquiry.

10   Fischbacher, U. and S. Gachter (2010). "Social preferences, beliefs, and the dynamics of free riding in public goods experiments." The American Economic Review 100(1): 541-56.

11   Fischbacher, U., S. Gächter and E. Fehr (2001). "Are people conditionally cooperative? Evidence from a public goods experiment." Economics Letters 71(3): 397-404.

12   Gächter, S., E. Kessler and M. Königstein (2008). "Performance incentives and the dynamics of voluntary cooperation." University of Nottingham, School of Economics. At: UUhttp://www. nzae. org. nz/conferences/2008/100708/nr1215383825. pdf.

13   Gächter, S. and E. Renner (2010). "The effects of (incentivized) belief elicitation in public goods experiments." Experimental Economics: 1-14.

14   Harbring, C. and B. Irlenbusch (2003). "An experimental study on tournament design." Labour Economics 10(4): 443-64.

15 Herrmann, B. and H. Orzen (2008). "The appearance of homo rivalis: Social preferences and the nature of rent-seeking." Discussion Papers 10.

16 Lazear, E.P., Rosen, S., 1981. Rank-order tournaments as optimum labor contracts. Journal of Political Economy 89, 841–864.

17 Li, J., E. Xiao, D. Houser and P. R. Montague (2009). "Neural responses to sanction threats in two-party economic exchange." Proceedings of the National Academy of Sciences 106(39): 16835.

18 Solow, R. M. (1971). "Blood and thunder." Yale Law Journal 80(8): 1696-711.

19 Titmuss, R. (1971). "The gift relationship: From human blood to social policy." London and New York.

Appendix A

In part 1 of the experiment, via strategy method we obtain a complete contribution table for each subject indicating how much s/he is willing to contribute depending on the other's group member unconditional contribution. Using this information, following FGF (2001), we can classify subjects as follows:

a. *Conditional Cooperators*: subjects who show either a monotonic pattern with at least one increase or have a positive Spearman rank correlation that is significant at the 1%-level;

b. *Free riding*: all subjects who contribute 0 in any case;

c. *Triangle Contributors*: subjects who have a significantly increasing scheme up to some maximum and a significantly decreasing scheme thereafter, again using the Spearman rank test at the 1% level as the criterion ("hump-shaped contributions").

d. *Others:* all subjects who cannot be classified in the previous categories.

The types' classification for each treatment is showed in table 3 where, the last column reports the FGF, (2001) classification' results. In comparison with FGF, we observe a lower share of triangular contributors.

Table I reports the type's classification across the whole experiment

Table I. Subjects' classification in the whole experiment.

	VC&VC	T&VC	PR&VC	ST&VC	VC&VC(b)	T&VC(b)	seqVC	seqT	Tot	Reference: FGF,2001
% Selfish	16.67	12.5	7.50	7.14	17.86	8.33	14.58	13.64	12.21	29.55
% Conditional cooperators	66.67	60.71	77.50	62.50	71.43	70.33	62.50	61.36	65.70	50
% Triangular contributors	–	8.93	–	7.14	7.14	–	6.25	2.27	4.36	14
% Other	16.67	17.86	15	23.21	3.57	20.83	16.67	22.73	17.73	6.82
N° subjects	**48**	**56**	**40**	**56**	**28**	**24**	**48**	**44**	**344**	**44**

The types' distribution does not statistically differ across treatments, χ^2 test p-value 0.597. In the same way, types distributions do not differ if we consider subgroups of treatments: VC&VC, T&VC and ST&VC (χ^2 test p-value 0.336); VC&VC, T&VC, seqT and seqVC (χ^2 test p-value 0.698) and finally VC&VC and T&VC with and without beliefs elicitation (χ^2 test p-value 0.331).

Appendix B

In this Appendix we present the Instruction provided to the participants.

Part 1
Part 1 of the experiment is identical for all the treatment run.

Instructions for the participants

Welcome to this economic experiment
Your decisions and the decisions of other participants influence your payment in this experiment. Hence, it is important to read these instructions carefully. If there is any open question, please contact us **before** the experiment starts. All participants receive the same instructions.

During the experiment, you are not allowed to speak with another participant. If you ignore this rule, we exclude you from the experiment and any payment.

During the experiment we calculate your earnings with points. At the end of the experiment, we convert the final score into pounds, using the following exchange rate.

5 points = 1 €

The experiment has two parts. At the end of the entire experiment, you receive your total earnings from both

parts of the experiment **in cash**. Now we explain the first part of the experiment. You receive the instructions

for the second part later.

The decision making context
Now we explain the general context in which you can make decisions. We then show you all the relevant details for your decision. At the end you find some exercises which should make you more familiar with the experiment.
You are part of a **group with 2 members, that is, besides you there is one other group member**. Each member has to allocate 20 points. You can store these points in a private account, you can also use **some or all** of these points to make an input. Each point that you do not use for your input, remains in your private account.
Please consider: In the second part of the experiment you will not form a group with this other group member anymore. In each part of the experiment the group composition is different.
<u>Earnings from the private account</u>

You earn one point for any point that you put into your private account. For example, if you put 20 points into your private account (and therefore make no input), you earn 20 points from the private account. If you put 6 points into this private account, you earn 6 points. *No one else receives a payment from your private account.*
<u>Earnings from your input</u>

Both group members benefit from your input in the same way. Likewise, your earnings also increase with the input of the other group member. A group member's earnings from both inputs is determined in the following way:

Earnings from the inputs = Sum of inputs × 0.75

If, for example, both group members contribute 20 points altogether, each group member receives 20 × 0.75 = 15 points.

Total earnings:

The earnings from your private account and the earnings from the inputs add up to your total earnings:

> *Earnings from your private account (= 20 − your input)*
> *+ Earnings from the inputs = Sum of inputs × 0.75*
> *Total earnings*

The Experiment

The experiment captures the decision making process as it is described above. We pay you according to your decisions at the end of the entire experiment. We conduct this part of the experiment only once.

As you know, you can allocate 20 points in your private account or as an input. You have to make two different input decisions which we call **unconditional input** and the **input table**.

- The **unconditional** input determines how many of the 20 points you want to use for your input independently of the other member's input. You just type the relevant number in the following computer screen:
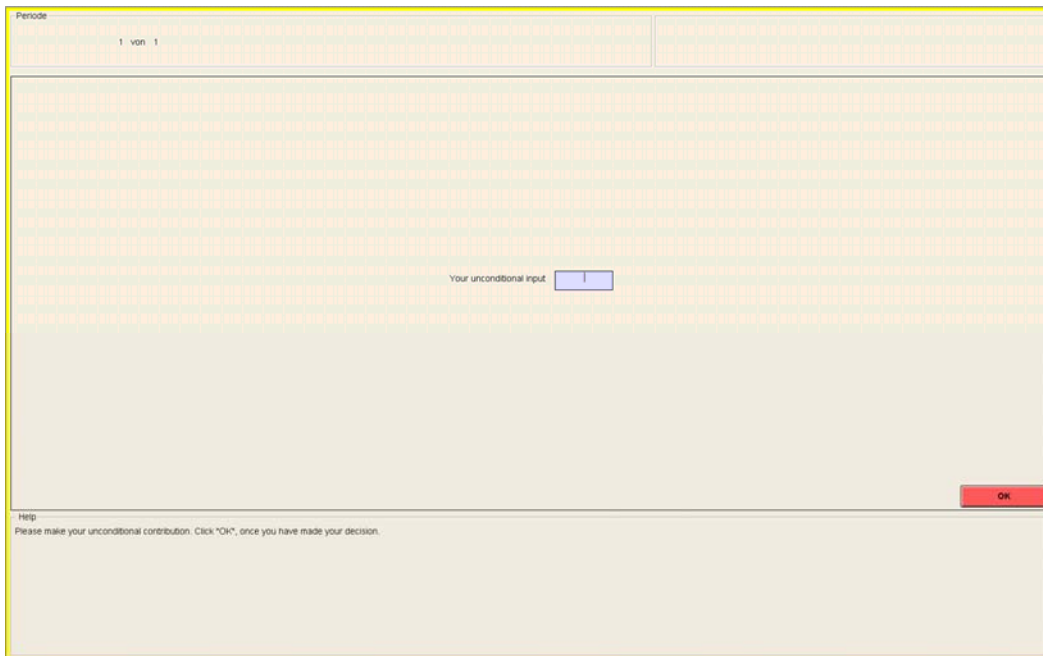
Once you have decided about your unconditional input please click „OK".

- Then you have to fill an input **table as follows.** In this table you decide about **your input for each possible input of the other group member.** Hence, you can adjust your input according to the input of the other group member. The following screen shot shows you the input table. It appears once you have made your unconditional input.

Your conditional input (input table)

0		7		14	
1		8		15	
2		9		16	
3		10		17	
4		11		18	
5		12		19	
6		13		20	

OK

Help
Please state in each box your input according to the in put of the other participant (shown on the left side of the box). Once you have made all your decisions, click "Ok".

The numbers to the left of the blue text fields show the possible input of the **other** group member. In each text field you type in **your** input assuming that the other has made the input stated on the left. **You must type a number in each field.** Hence, you must make an input decision if the other group member has made an input of 0 points, if the other group member has made an input of 1 or 2 or 3 points and so on. In each field you can write an integer between 0 and 20.

After you have typed a number in each field, please click "OK".Once all participants in all groups made their all their input decisions, one group member in each group will be randomly selected. For this **randomly selected group member**, the **input table** determines the actual input. For the **other group member** (which has not been randomly selected), the **unconditional input** determines the actual input. Since this random selection takes place after you have made your decisions, you do not know which input decision will be relevant. Hence you should consider both input decisions carefully because any decision could become relevant. Two examples help to clarify this aspect:

Example 1: Suppose you have been selected by the random mechanism. Hence your input table is relevant, while for the other group member the conditional input is relevant. We assume that this other group member has chosen an input of 2 points.

If you have put an input of 1 into the input table and the other group member has put in 2, then the total input is 3 points (1+2). Each group member therefore earns 0.75×3=2.25 points from the inputs and the resulting income from the private account (which is equal to 17).

If you have decided instead that you make an input of 19 if the other group member has chosen 2, then the total input is 21 points (19+2). Each group member therefore earns 0.75×21=15.75 points from the inputs plus the resulting income from the private account (which is equal to 1 in this example).

Example 2: Suppose you have not been selected by the random mechanism. Hence your unconditional input is relevant. Suppose this unconditional input is 16.

If the other group member inserted an input of 1 into the input table and you have chosen 16, then the total input is 17 points (1+16). Each group member therefore earns 0.75×17=12.75 points from the inputs and the resulting income from the private account.

If the other group member has decided to make an input of 19 if you have chosen 16, then the total input is 35 points (19+16). Each group member therefore earns 0.75×35=26.25 points from the inputs and the resulting income from the private account.

The computer makes the random selection. For the moment you will not receive any information about the choices and earnings of the other group member in this part. We will provide this information at the end of the experiment. We will register the number of points you will obtain and we will pay them out together with the earnings of the other part.

Exercises:

Please answer all the following questions. They should make you familiar with the calculation of your earnings depending on the allocation of the available 20 points. *Do not show just results but also the way you derived the results.*

1. Each group member has 20 points available. No group member (including yourself) makes any input.

What are your total earnings?..........

What are the total earnings of the other group member? ....

2. Each group member has 20 points available. You make an input of 20 points, the other group member also makes an input of 20 points.

What are your total earnings?..........

What are the total earnings of the other group member? ....

3. Each group member has 20 points available. The other group member makes an input of 10 points.

a) What are your total earnings, if you make an input of 0 points on top of the 10 points?

b) What are your total earnings, if you make an input of 8 points on top of the 10 points?

c) What are your total earnings, if you make an input of 15 points on top of the 10 points?

4. Each group member has 20 points available. You make an input of 8 points.

a) What are your total earnings, if the other group member makes an input of 7 points on top   of your 8 points?

b) What are your total earnings, if the other group member makes an input of 12 points on top   of your 8 points?

c) What are your total earnings, if the other group member makes an input of 3 points on top   of your 8 points?

5. How many parts does the experiment have?

How does the group composition change between the different parts?

6. What is the difference between the unconditional and the conditional input (input table)?

7. When do you receive information about the payments?

If you finish early you may think about further exercises to make yourself more familiar with the experimental set up.

Part 2

Part 2 of the experiment differed across treatment. Decision 1 was identical for all treatments but for VC&VC(b) and T&VC(b) since in these two treatment beliefs about others' group member choices were elicited.

Instructions for the participants

Welcome to the second part of this economic experiment

During the experiment, you must not speak with another participant. If you ignore this rule, we exclude you from the experiment and any payment.

During the experiment we calculate your earnings with points. At the end of the experiment, we convert the final score into pounds, using the following exchange rate.

5 points = 1 €

The experiment has two parts. At the end of the entire experiment, you receive your total earnings from both parts of the experiment **in cash**. Now, we explain you the second part of the experiment.

This part of the experiment covers several periods. each participant is always member in **two groups** (group 1 and group 2). Both groups have two members each. Hence, there is one other participant in each of your two groups. None of these participants was in your group during the first part of this experiment. The group member in group 1 is another person than the group member in group 2. Hence, **you are the only person who is both in your group 1 and in your group 2.**

The group composition does not change across the periods. In group 1 you face the same participant in each period. The other group member in group 2 does not change either.

We will **pay only one of these periods** at the end of the experiment. The computer will select this period randomly. In the selected period, we will pay you the earnings you obtained from both groups.. Since you do not know which period the computer will randomly select, you should decide carefully in each period.

Now we explain you the second part of the experiment in detail.

At the beginning of each period, each participant receives **20 points** for group 1 and another **20 points** for group 2. We call these 20 points the **endowment**. You have to decide how to use these endowments. In each group you must decide how many points out of 20 you want to use as an input and how many points you want to keep.

Your potential income in a group in each period depends on your input and the input of the other group member. Two components determine **your earnings in each group:**

(decision 1 was different in each treatment)

Group 1 (VC&VC treatment)

Two components determine your income in group 1:
(1) the points you keep for yourself ("**earnings from the retained points**") and
(2) the "**earnings from the inputs**". These earnings from the inputs are calculated in the following way:

Your earnings from the inputs =
0.75 × sum of the inputs of both group members

Therefore, your earnings from the input in a period in group 1 (respectively group 2) is
(20 − Your input) + 0.75*(sum of the inputs of both group members).
The earnings of the other group member add up in the same way. Both group members receive the same amount of points from the inputs. If the sum of inputs is 30, for example, then each group member receives 0.75 × 30 = 22.5 points. If both make inputs of altogether 8 points, each group member earns 0.75 × 8 = 6 points.
These earnings from the retained points are calculated in the following way: you earn 1 point with every point that you keep.
Therefore, every point that you use as an input increases the sum of the inputs by 1 point. Your income from this sum of the input increases by 0.75 points. However, the earnings of the other group member increase by 0.75 points as well. Hence, any point of input increases the overall earnings of the entire group by 0.75 × 2 = 1.5 points. In consequence, the other group member benefits from your inputs and you benefit from the inputs of the other group member.

Group 1 (T&VC Treatment)

Two components determine your income in group 1:
(1) the points you keep for yourself, (**"Income from retained points"**) with **4 points = 1 pound,** and
(2) the **"Income from the input"**. This income from the input is calculated in the following way.

Income from the input =
- If your input is larger than the input of the other group member you receive 40 points.
- If your input is smaller than the input of the other group member you receive 0 points.

- If both inputs are equally large, the computer decides randomly which member receives 40 points and which member 0 points.

Hence, your potential income per period in group 1 is

(20 − your input) + 40 (if your input is larger or if the computer has chosen you in case of equal inputs)

(20 − your input) + 0 (if your input is smaller or if the computer has chosen the other group member in case of equal inputs)

The earnings of the other group member add up in the same way. Both group members receive the same amount of points from the inputs. For example, when each group member makes an input of 15 points, then only one of them receives 40 points. Similarly, when each group member makes an input of 4 points, then only one of them receives 40 points. Each point you retain earns you 1 point. Each point you use for input can bring you 40 points if it leads to a higher or equally large input than the other group member's one. In return, you can receive 0 points if an input increase by the other group member leads to a higher or equally large input than yours.

Group 1 (PR&VC treatment)

Two components determine your income in group 1:

(1) the points you keep for yourself, (**"Income from retained points"**) with **4 points = 1 pound,** and

(2) the **"Income from the input"**. This income from the input is calculated in the following way.

Input	0	1	2	3	4	5	6
Income from the input	0	2	3.9	5.7	7.4	9	10.5
Input	7	8	9	10	11	12	13
Income from the input	11.9	13.2	14.4	15.5	16.5	17.4	18.2
Input	14	15	16	17	18	19	20
Income from the input	18.9	19.5	20	20.4	20.7	20.9	21

We use the same table to calculate the income of the other group member, i.e. each group member gets the same income from a given input. If each group member makes an input of 15 points then you receive 19.5 points and the person as well. If each group member makes an input of 4 points then you receive 7.4 points and the person as well. You earn 1 point for each point that you retain.

Treatment VC&VC and VC&VC(B): **We calculate the earnings in both groups in the same way.**

Other treatments: T&VC, PR&VC, seqT seqVC)

Group 2 **Two components determine your income in group 2:**

(1) the points you keep for yourself ("**earnings from the retained points**") and

(2) the "**earnings from the inputs**". These earnings from the inputs are calculated in the following way:

> Your earnings from the inputs =
> 0.75 × sum of the inputs of both group members

Therefore, your earnings from the input in a period in group 2 is

(20 – Your input) + 0.75*(sum of the inputs of both group members).

The earnings of the other group member add up in the same way. Both group members receive the same amount of points from the inputs. If the sum of inputs is 30, for example, then each group member receives 0.75 × 30 = 22.5 points. If both make inputs of altogether 8 points, each group member earns 0.75 × 8 = 6 points. These earnings from the retained points are calculated in the following way: you earn 1 point with every point that you keep.

Therefore, every point that you use as an input increases the sum of the inputs by 1 point. Your income from this sum of the input increases by 0.75 points. However, the earnings of the other group member increase by 0.75 points as well. Hence, any point of input increases the overall earnings of the entire group by 0.75 × 2 = 1.5 points. In consequence, the other group member benefits from your inputs and you benefit from the inputs of the other group member.

At the beginning of each period you see the following screen

On the top to the left you see the current **period number**.

Treatment PR&VC

Treatments T&VC (b) and VC&VC (without the beliefs section); treatment seqT only decision 1 on the screen.

Period	
2	

Group 1	Group 2
Your input in the previous period 8	Your input in the previous period 8
Input of the other group member in the previous period 9.0	Input of the other group member in the previous period 8.0
Your prediction regarding the other group member earned you 2 points	Your prediction regarding the other group member earned you 3 points
Your potential income in the previous period 14.00	Your potential income in the previous period 27.00
Your endowment 20	Your endowment 20
Your input [ ]	Your input [ ]
The group member with the higher input receives this amount of points 40 The group member with the lower input receives this amount of points 0 With equal inputs a lottery decides.	Each group member receives the input of both group members, which is multiplied by the following factor 0.75 Both group members receive equal shares of these joint inputs
Which input will the other group member choose? [ ] Recall that a correct answer is rewarded.	Which input will the other group member choose? [ ] Recall that a correct answer is rewarded.

OK

Treatments VC&VC (b) VC&VC (without the beliefs section); treatment seqVC only one decision on the screen.

Below the header, the screen is separated in two parts. To the left you see all information for group 1, to the right all information for group 2. In each group you see your input in the previous period, the input of the other group member in the previous period and your potential income in the previous period. Of course, this information is missing in the first round.

Note: **Group 1 and Group 2 are independent groups**. Therefore you can decide separately for each group. **Your input in Group 1 can be higher, of equal size or smaller than your input in Group 2.** In each Group, you have an endowment of 20 points in each period.

This part indicated here in bold was present only for treatment VC&VC(b) and T&VC(b)

In the lower half of the screen we ask you to predict the input of the other group member in each group. You will be paid for the accuracy of your estimate:
- **If your estimate is exactly the choice made by the other group member), you will get 3 points in addition to your other gains from the task.**
- **If your estimate deviates by one point from the actual choice of the other group member, you will get 2 additional points.**
- **A deviation by 2 points earns you 1 additional point.**
- **If your estimate deviates by 3 or more points from the actual choice the other group member made, you will not get any additional points.**

Once you have made all your decisions, please click the OK button. Once you have clicked the button you cannot revise your decision in this period anymore.

Once all group members made their decision, one period is over. Then you see a new input screen for the next period, which contains information about the inputs in the past period and the resulting potential earnings. The earnings are potential because we pay only one randomly chosen period. Then you can make your decisions for the next period.

Questions:
Please answer all the questions and show how you made your calculations. Please contact us if you have any question.

1st Question
  How many periods do we actually pay?

2nd Question
  In Group 1 no participant makes any input. In group 2 both you and the other group member make an input of 20 points each.
Calculate
- Your potential earnings in group 1: ....
The potential earnings of the other group member in group 1:
- Your potential earnings in group 2: ....
The potential earnings of the other group member in group 2:

3rd Question
  In group 1 the other group member makes an input of 15.
  In group 2 the other group member also makes an input of 15.
Calculate
- Your potential earnings in group 1, if you make an input of 10 on top of the 15 points.
- Your potential earnings in group 1, if you make an input of 0 on top of the 15 points.

4th Question
  In Group 1, your input is 16 points:
Calculate
- Your potential earnings in group 1, if the other group member makes an input of 17 on top of the 16 points.
- Your potential earnings in group 1, if the other group member makes an input of 2 on top of the 16 points.

Part 3
Part 3 was identical to part 1 and was only run in treatment seqVC and seqVC

Chapter 3

Selective Attention to
(Useless) Information about Peers

CHAPTER PREVIEW: We run an experiment to test the impact of peers effect on individual productivity under piece rate incentives. Along 15 repetitions, being informed about their productivity, participants choose an initial effort level which they can revise after a feedback on result. Knowing that the optimal effort choice may differ across subjects, half of the participants received also a feedback about the initial choice and the results of another participant in the room without knowing her/his productivity. Despite the fact that information about peer is useless in determining the individual optimal effort, we find that individuals manifest *selective attention* to information about peer. In particular, those subjects informed that the peer obtained a higher result have a higher probability to revise their initial choice and a higher probability to revise it optimally.

3.1   Introduction

In workplace, the existence of repetitive and long term interactions among employees makes information about colleagues' activities and performances easily obtainable, especially for workers at the same hierarchical level. Even "individual" job activities are often conducted in places where other workers are presents (e.g. shared offices, open spaces, etc). Therefore, in many circumstances workers are able to observe each other and, especially if they perform similar tasks receiving similar rewards, it is also likely that they can acquire precise information about colleagues. These features make the workplace a favored environment for horizontal comparisons to take place, Gächter and Töni (2010). In particular, since the individual tendency to compare becomes stronger as the referent other is similar, it is not surprising that co-workers are often taken as reference group for comparisons, Festinger (1954); Clark and Senik, (2009). Therefore, assessing whether and through which channels colleagues have an influence on individual productivity deserves to be investigated since it is rich of implications for the job design in organizations. Actually, the potential effects of information about colleagues earnings on work morale (and overall performance) seems to be acknowledged by

managers, which are also aware that workers have an idea about respective earnings, despite the fact that in many organizations salaries are officially kept secret, (Bewley, 1999). Similarly, in fixing the degree of wage compression, managers aim to impact on work morale and team spirit, (Lazear 1991).

In this paper we present a lab-experiment which analyzes the impact of information about colleagues' actions and earnings on individuals who perform a simple individual decision making task under a piece rate incentive scheme.

The study of peer effects is a research topic for which the use of laboratory experiments is particularly suitable. Laboratory experiment, indeed, allow for extensive control of many of the confounding factors which are instead present in real data (e.g. working conditions, self selection effects, etc), making very complicated the identification of the social interaction effect, Manski, (1993). For example in an organization, a first form of peers' influence may simply be due to the contemporaneous presence of several workers in the same place. In fact, the 'social facilitation paradigm', Zajonc (1965), evidences how the mere presence of others is sufficient to affect positively (social support) or negatively (social pressure) the individual behavior and performance in simple tasks, Dohmen, (2005). In addition, at a different level, peers' effect may interact with the incentive schemes adopted in the organizations, reinforcing or undermining the individual motivation to perform and the consequent achievement of organizational goal.

Indeed, while under fixed payment schemes peers effect seems to lead net productivity gains for organizations (Falk and Ichino (2006); Mas and Moretti (2009)), once we take in account different compensation schemes, the experimental evidence on workers' productivity linked to peer effects becomes puzzling. When workers are paid fixed wages, the presence of peers induces a significant increase in individual productivity, especially for the least productive workers. In the field experiment by Mas and Moretti (2009)[30], however, this positive effect is fostered by the presence of externalities among agents' actions while, in the field experiment by Falk and Ichino (2006) positive effects on productivity are evidenced even when agents' activities are not interconnected, (even though in this study it is not possible to disentangle learning from social support). In a laboratory experiment, Thöni and Gächter (2010), using a three-person gift exchange game (one firm-two workers), evidence that the inclination to reciprocity towards the firm is interdependent among the workers. When workers are informed about the behavior of colleagues, knowing that the colleague behaves reciprocally (egoistically) makes a worker reciprocal (egoistical) himself.

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[30] The work of Mas and Moretti (2009) investigates something stronger than peer effect: peer *pressure*, as described in Kandel and Lezaer (1992). Peer pressure has two essential features. First, each worker's must

Differently, the impact of peer effects in presence of explicit monetary incentive to perform is more controversial. In a laboratory experiment, Sausgruber (2009) evidences that the information about the performance of a team does not increase the performance of another team, although it reduces the variation of the outputs between teams. In a filed experiment, Bellemare et al. (2009) compare the productivity of workers exposed to peer effects under piece rate and fixed wage, but they do not find any level of peer effects which increases productivity. Moreover, under piece rate a small but significant negative effect on individual productivity is documented for very high and very low level of peer pressure, measured as the information about the other's productivity.

Standing on this mixed evidence, we present laboratory experiment which investigates the basic mechanism of peer effect acting through information about peer in a context in which individual earnings only depend on individual behavior. Moreover, ruling out by design the impact of other regarding preferences and learning on individual behavior, we are able to discriminate about content of the information and its different impact on behavior.

Along 15 repetitions, participants in our experiment are first informed about their productivity and then choose their initial effort level, which they can revise after a feedback on results. Knowing that optimal choices may differ across subjects, half of the participants receive also a feedback about the initial choice and the points earned by another participant in the room. The first effort choice is the *initial effort* and is by construction independent of social interaction effects, at least in the first repetition. The second effort choice is called the *revised effort* and it identifies the marginal influence of social interaction. The difference between the initial and the revised effort is attributed to the information about the other worker's effort and earnings. Since participants are not informed about other's productivity, the information received is useless in the revised effort choice. Nevertheless, we find that participants manifest *selective* attention toward information about peer. Individuals focus only on information which report their worse relative position (in terms of effort choices and or earnings) compared to a peer. Seeing that a peer is earning more increases the worker's probability of revising the initial choice, and moreover, it increases the probability of revising it optimally.

Our design allows controlling both the peer who is made relevant for the comparison and the content of peer information. Dealing with social comparison, indeed, it is not obvious who the worker chooses as reference since both upward and downward social comparisons may take place, Suls, Martin & Wheeler (2002). Finally, being the workers' actions and payoff function not interconnected in the piece rate incentive scheme, each worker is not affected by others and similarly s/he does not affect

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affect the well-being of the rest of the team. Secondly, the team members must have the ability to affect the choices of the single worker.

the others' outcome. In this way other regarding preferences are excluded by design from the decision situation and therefore, we are able to isolate the pure effect of receiving (useless) information about peers.

Our design is very conservative because it only exploits information about peer for testing the relevance of peers effect. On the contrary, in real workplaces many other factors, jointly with information about peers, may play a role in affecting individual behaviors in presence of peers. Therefore, if it is possible to show that even in the laboratory a subject's decisions is affected by (useless) information about an anonymous other subject it is likely that peers' effects play an even more important role in the workplaces, deserving to be better investigated by managers, which are able to influence the information available to employees.

Our main result is that receiving (useless) information about peer does not automatically activate peer effect, rather, learning that the peer is obtaining a higher result it is sufficient to significantly increase both the probability of revision of the initial choice and, more importantly, the probability of revising in an optimal way those initial choices that were suboptimal. Even though the information about peer does not convey information about her/his productivity (and therefore it in useless in the revision stage), learning to be behind the peer seems to foster the revision of the initial choices, alimenting a mechanism that induces the subjects to revise critically his/her choice.

In this sense our result is similar to Mas and Moretti and Falk and Ichino if we consider that peer effects lead, in their setting to increase the productivity of the "weakest" worker, while to ours it and increase in the probability of reaching an optimal choice. In our experimental setting, however, we are able to control for the type of information received by the peer informed subjects. In Mas and Moretti, for example, workers were able to observe each other, but, we cannot disentangle which fraction of the observed increase in productivity is due to the fear to be socially punished by more productive colleague, or some form of other regarding preferences, since the workers action are interdependent and the low productive workers imposes negative externality on the colleagues.

Finally, we are also able to exclude learning by observing the other, which may play a role in the field experiment by Falk and Ichino. In this sense, our experiment provides evidences of peers effect in the most conservative environment and results can be interpreted as an indicator of the "lower bound" of the relevance of peer effect.

The paper is organized as follows: Section 2 presents the experimental design, Section 3 discusses the hypothesis of the research, Section 4 presents the results and Section 5 concludes.

3.2   Experimental Design and Procedures

We use a very simple individual decision making task to test the relevance of information about peer. Each participant faces 15 repetitions of a simple task. In each period s/he is informed about her/his productive factor mp, $mp \in \{1,..,9\}$ and s/he has to chose an *initial* effort level (e_1) in the set $e_1 \in \{0,..,10\}$, to which a cost is associated. The cost function is increasing in effort and it is determined in the following way: $c(e_1)=0.5 \cdot e_1^2$. The individual result, in experimental points (1 experimental point= 0.3 €), is determined according to the following formula:

$$Result = e_1 \cdot mp - c(e_1) \tag{1}$$

therefore the optimal effort for each individual corresponds to her/his productive factor an s follows:

$$e_1 = mp \tag{2}$$

In each repetition, after the initial effort (e_1) is chosen, every participant is showed a feedback screen containing his result in experimental points. It is common knowledge that, for all the repetitions, 50% of participants will receive in their feedback screens also information about the choice made by another anonymous participant and the points s/he earns. After the feedback screen, the participants enter a revision screen, where they can revise or confirm their initial choice, given the same productive factor mp. We denote the revision effort choice as e_2.

Subjects are informed that the productive factor mp may differ across subjects, therefore, once they receive information about the choice and the result of a peer, this information is useless and therefore they should not affect the stage of the effort revision of the peer informed subject.

In each session we have two treatments which only differ for the content of the feedback provided to the subjects. In the *peer* treatment after each repetition, subjects receive information about other's choice and earnings in addition to the information about own results. In the *control* treatment subjects only receive information about own results. In both treatments the subjects' results only depend on the individual decision, so there are no externalities among the individual choices. Moreover, even in the case in which the participant wants to confirm the initial choice they have to re-type the choice in the input box on the screen. Therefore, the cost of submitting a revised effort or confirming the initial choice is the same.

Participants are informed that only the result they obtained in one over 15 periods is going to be randomly selected to become relevant for the final payment. If in the period selected to be payoff relevant the participant revised her/his initial choice, the final earnings will be determined by the initial choice (e_1) with 50% of probability, and by the revised choice (e_2) otherwise. The design is such that, *when participants behave optimally*, 2/3 of the peer informed subjects receive information both about higher and lower choices (and profits) of another participant. 1/3 of the peer informed subjects will receive, for all the 15 repetitions, information about a peer facing the same mp. Our design is particularly restrictive, since we do not allow for any kind of interconnections between agents' payoff functions, we control the "referent other", by holding it fixed in the entire session.

The experiment has been conducted at the LES (Laboratorio di Economia Sperimentale) University of Bologna- Forlì Campus in October 2009. A total of 72 undergraduates from Economics, Political Science, Language and Engineering participated, divided in three sessions; the majority of them were female: 67.5% and most of the participants were not experienced. The average subjects earned 10 euros within approximately 50 minutes. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). The experiment was framed in a neutral language.

3.3   Prediction and Hypothesis

In this section we briefly present the behavioral hypothesis tested in this experiment.

The standard economic predictions do not contemplate peers effect. Therefore, in the decision setting of our participants, since the additional information provided in the peer treatment does not reveal the peer's productivity, it is useless and there are no reasons to consider it in the effort revision stage. Hypothesis 3.1 summarizes this view:

> **HYPOTHESIS 3.1**. *No Peer Effect Hypothesis*: The probability of effort revision does not differ across treatments.

On the contrary, if peer effects have economic relevance, the alternative hypothesis has to be verified:

> **HYPOTHESIS 3.2**. *Peer Effect Existence Hypothesis* The probability of effort revision is higher in the peer treatment.

While in hypothesis 3.1 and 3.2 we considered simply the probability of revision of the initial choices, in next hypothesis we will focus on the probability of revising suboptimal choices. If we observe peer effect in this case, it is interesting also to analyze whether receiving information about peer increase the probability of optimal revision of the suboptimal (initial) effort choice. If this is the case, indeed, information about peer fosters a peculiar form of learning between participants. According to standard economic prediction we should not observe differences across the two treatments, as stated in hypothesis 3.3:

> **HYPOTHESIS 3.3**. *No Learning Effect Hypothesis*: The probability of revising in an optimal way an initial (suboptimal) effort choice does not differ across treatments.

The alternative hypothesis is that

> **HYPOTHESIS 3.4**. *Learning Effect Existence Hypothesis* The probability of revising in an optimal way an initial (suboptimal) effort choice is higher in the peer treatment.

3.3.1 The content of information about peer

From hypothesis 3.1- 3.4 we assumed that receiving information about peer has an effect independently from the content of such (useful) information. In next set of hypothesis we will discriminate across the content of the information about other's earning and effort received by the subject in the peer treatment.

The hypothesis 3.5 assumes that receiving information about peer is sufficient to activate peer effects, independently form the content of such information.

> **HYPOTHESIS 3.5**. *Peer effect equivalent to peer information:* Receiving any information about peer's effort and earnings affects the individual behavior.

An alternative hypothesis assume that peer effects are activated when a subject is informed that the other is behaving differently than her/him, as stated in hypothesis 3.6:

HYPOTHESIS 3.6. *Peer effect not equivalent to peer information(1):* Learning that the other   is choosing a different effort level or is obtaining different earnings does affect the individual behavior.

Finally, hypothesis 3.7 and 3.8 are two variations of hypothesis 3.6 and assume that a subject's behavior is affected when learning that the other is choosing higher (lower) effort and s/he is obtaining greater results.

HYPOTHESIS 3.7. *Peer effect not equivalent to peer information (2):* Learning that the   other is choosing a higher effort level or is obtaining greater earnings does affect the   individual behavior.

HYPOTHESIS 3.8. *Peer effect not equivalent to peer information (3):* Learning that the   other is choosing a lower effort level or is obtaining smaller earnings does affect the   individual behavior.

Hypothesis 3.7 (3.8) assume that, when a subject receives negative (positive) feedback because the other chooses the same or an lower (higher) effort level and realizes the same or a lower (greater) result, these information do not affect in a significant way the subject's revision choice. Therefore, according to this hypothesis we should observe no significant difference among those subjects who are in the peer treatment but learn that the other is choosing lower (higher) effort and gaining less (more) and those who are in the control treatment.

3.4 Results

In this section we present our results. We first present some summary statistics and then we concentrate on the subjects' revision behavior analyzing in particular how being exposed to information about peer affect the probability of revision of the initial choice.

The 23.6% of initial choices are suboptimal and after the revision stage, this percentage decreases to 19.7%. Figure 1 shows how the suboptimal effort choices distribute across subjects before and after the revision stage.

Despite the simplicity of the task, around 60% of the subjects make between 1 and 5 suboptimal choices, which correspond to 1/3 of the choices. Therefore, our analysis is not based on few subjects who did not understand the game.
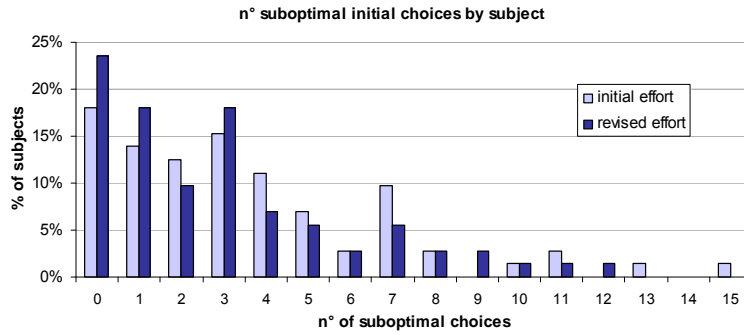
Figure 1. Percentage of subjects choosing suboptimal effort

Suboptimal choices are decreasing over the 15 repetitions, therefore despite the simplicity of the task, there is room for some learning to occur, as showed in Figure 2. In 10.9% of the cases the initial choices are revised but if we consider suboptimal choices the percentage of revision is equal to the 39.61%. Interestingly, in the majority of the cases, suboptimal choices are not revised. Optimal initial choices are (sub optimally) revised in 2.06% of the cases.
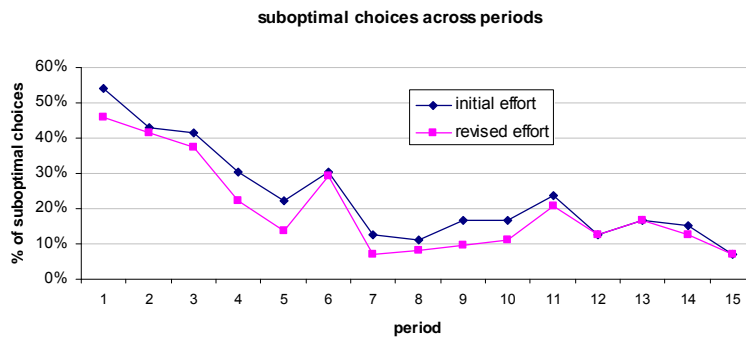
Figure 2. Percentage of subjects choosing suboptimal effort

In next sections we present in details our results. First, we concentrate on how, being exposed to information about peer, does influence both the probability of effort revision (section 4.1) and the probability of optimally revision of a suboptimal initial effort choice (section 4.2). In both sections, we first look at the impact of receiving information about peer without discriminating on the content of such information. Then, we will investigate whether peer effects are automatically activated once information about peer is provided, or, if they depend on the content of the information about peer.

3.4.1 The initial choice revision

In this section we analyze whether being exposed to information about peer affects the individual probability to revise the initial choice. We present our first result.

Result 1

Learning that the peer is obtaining a higher result increases the probability of   revising the initial choice.

Support for this result is provided in three steps: first, from table 1 which contains summary statistics. The second steps investigate how information about peer which differ by content, affects differently the individuals' behavior. Finally, we estimate a Logit model on the probability of revision.

In table 1, the percentage of revision of choice both in the peer treatment and when subjects learn that the other is earning more. If we consider the dummy *peer*, which identifies the provision of peer information (without discrimination on the content), in every single period (except for period 14 and 8) there are no statistically significant differences in the percentage of (initial) optimal choices and of revision choices across treatments, both t-test and Mann Whitney test. Finally, if we focus only on the percentage of revision of those (initial) choices which were suboptimal, we do not find difference statistically significant both across all period (t-test, p-value 0.1016 and Mann Whitney test, p-value 0.1015) and in every single period.

Table 1.Percentage of revision choices by treatment

	Peer Treatment	Control treatment	Subjects informed that the other is earning more	Other (Control treatment)	Total
% of revisions	13.15	8.70	23.90	7.89	10.93
Std. dev	.3382	.2822	.2390	.2697	.3121
% revision (for suboptimal initial choice)	44.06	33.93	55.13	32.77	30.59
Std. dev	.4982	.4756	.5006	.4707	.4617

On the contrary, if we consider those subjects who receive information about higher results by the peer, the percentage of revision is significantly higher for those subjects than for subjects who do not receive any information and who learn they are obtaining equal or higher results, t-test p-value

0.0000 and Mann Whitney test, p-value 0.0008[31]. Similarly, if we only consider the probability of revising the suboptimal (initial) choices, the percentage of revision is significantly higher, (55.13 vs.32.77), t-test, p-value 0.0004 and Mann Whitney test p-value 0.0008.

Before to analyze whether receiving information about peers does affect the individual probability we focus on the content of information about peer received by subjects.

3.4.2 The content of peer information

In this section we show that peer effects are not automatically activated by receiving information about peer. In particular receiving peer information seems to affect significantly the individual behavior when it evidences that the referent other is obtaining a higher result than the peer informed subject. These findings are summarized in Corollary 1

Corollary 1
Learning that the other is obtaining a higher result does significantly affect the individuals' behavior.

In addition to the feedback about own results, subjects in the peer treatment receive both information about peer's initial effort and results (in experimental points). Therefore, we can identify different cases according to the type of information received, respectively about peer's initial choice and about peer's results (note that in our design, it is not necessarily true that a subjects choosing higher effort will obtain an higher result, since the optimal effort choice depend on the selected mp). Consider two subjects, i and j, being subject i the one who receives peer information about subject j, table 2 lists six possible cases. For each of them we create a new dummy. The idea is that, if subjects are sensitive only to specific types of information about peer rather than others, not receiving this specific information does not affect individual behaviors and therefore it is equivalent to not having peer information at all.

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[31] For those subjects who learn they are behind the peer, also the probability of revising an initially optimal choice in significantly higher (although very low in absolute terms) when peer informed subjects learn that the other is obtaining greater results, and it is equal to 4.72% in this case while 1.58% in the control group, t-test p-value 0.0108 and Mann Whitney test, p-value 0.0217.

Table 2- The content of peer information

The other is choosing/obtaining:	Dummy variables which discriminate on the content of information about peer.
Different result (Hp. 3.6a)	1 if $profit_i \neq profit_j$; 0...if $profit_i = profit_j$ AND if peer=0
Different effort (Hp. 3.6b)	1 if $e_i \neq e_j$; 0 if $e_i = e_j$ AND if peer=0.
Lower result (Hp. 3.8a)	1 if $profit_i > profit_j$; 0...if $profit_i \leq profit_j$ AND if peer=0
Lower effort (Hp. 3.8b)	1 if $e_i > e_j$; 0 if $e_i \leq e_j$ AND if peer=0.
Bigger profit (Hp. 3.7a)	1 if $profit_i < profit_j$; 0...if $profit_i \geq profit_j$ AND if peer=0
Bigger effort (Hp. 3.7b)	1 if $e_i < e_j$; 0 if $e_i \geq e_j$ AND if peer=0.

Since we are interested in analyzing the probability of revision, in order to test the relevance of the content of peer information, we test the alternative hypothesis contained in Table 4 through a Logit model where the dependent variable is the dummy *diff* which takes value 1 if the initial choice was revised and 0 otherwise. In the set of the independent variables we include the treatment dummy *peer* (which only discriminates on whether peer information was provided or not) the period, the gender and rep2 which takes value 1 if the marginal productivity parameter is selected more than two times during the 15 repetitions (in order to account for learning).

$$\text{Logit(diff=1)} = \Lambda(\psi_0 + \psi_1 \text{optimal1} + \psi_2 \text{peer} + \psi_8 \text{period} + \psi_9 \text{gender} + \psi_{10} \text{rep2}) \qquad (3)$$

For each of the dummies defined in table 4 we estimate model (3) on the observations for which the dummy of interest is equal to 0. In this way, in order to test the validity of each hypothesis we look the coefficient of *peer* in model (3): if it is not significant the hypothesis holds, and the fact that the coefficient of the dummy peer is not significant it means that not receiving the information contained in the dummy is equivalent to not receiving peer information at all.

Table 3 reports foe each of the Logit model estimated, the coefficient for the dummy *peer*. Looking Table 3 we can reject hypothesis 3.8 meaning that –using our examples, when subject *i* is informed that her/his earnings are higher than subject *j*'s ones- not receiving such information (namely, knowing that *j* is earning as or less than him) cannot be assimilated to the case in which subject *i* does not receive peer information at all.

Table 3. **_LOGIT estimations for Diff._**

The other is choosing/obtaining	Coefficient for the dummy _peer_
Different effort	-.0672625 (.4018106)
Higher effort	.1361495 (.3691344)
Lower effort	.4063068 (.3452106)
Different result	-1.327981 (1.152752)
Bigger result	-.2723429 (.4402908)
Lower result	.7120462* (.3500922)

The level of significance is shown with the following notation: *** (.000) indicates a p-value of the t statistic lower than 0.1%, ** a p-value between 0.1% and 1%. * indicates a p-value higher than 1% and lower than 5%, ^ indicates a p-value higher than 5% and lower than 10%. Std. Err in parenthesis. Adjusted for 72 clusters in subjects

Finally, as a further control we estimate a Logit model that includes in the set of the independent variables all the dummies contained in Table 3:

$$\text{Logit(diff=1)}= \Lambda(\zeta_0+ \zeta_1\text{optimal1}+ \zeta_2 \text{ lower result } +\zeta_3\text{lower effort}+ \zeta_4 \text{ bigger result } + \zeta_5$$

$$\text{bigger effort } + \zeta_6 \text{ different result } + \zeta_7 \text{ different effort } + \zeta_8 \text{ period}+ \zeta_9\text{gender}+ \zeta_{10}\text{rep2}) \quad (4)$$

The only two coefficients that are statistically significant are those for the variable _bigger profit_, (p-value 0.008) and _optimal1_, (p-value: 0.000)[32].

3.4.3 The probability of initial choice revision

In order to analyze whether receiving information about peers does affect the individual probability to revise the initial choice we estimate the Logit model in (5). The dependent variable is the dummy _diff_, which takes value of 1 if a revision took place, and 0 otherwise.

$$\text{Logit(diff=1)}= \Lambda(\gamma_0+ \gamma_1\text{optimal1}+ \gamma_2\text{peer}+ \gamma_3\text{time11}+ \gamma_4\text{time22}+ \gamma_5\text{period}+ \gamma_6\text{gender}) \quad (5)$$

---

[32] If we repeat the same analysis focusing on the revision choices of suboptimal (initial) choices, or on the optimal revision choices, the results do not change.

We include as independent variables gender (which takes value 1 if the participant is female), optimality of the initial choices (*optimal1* which takes value 1 if the initial choice was optimal and 0 otherwise), *time11* and *time22*, which denotes respectively the time used to submit the *initial choice* and the *revision choice*; the number of repetition of a given mp, to test for possible learning effects (*rep2*=1 if mp has been selected two or more times, 0 otherwise)[33]. Finally we include *period*[34] as a continuous variable.

The result of such estimation are reported in table 4 where, the different models only differ in the definition of peer effects used (namely the variable in the position of $\gamma_2$peer)[35] In model (1), we test for peer effects by including the treatment dummy variable *peer*. The results show no treatment effect: the coefficient of *peer* is positive but not significant. In Model (2) and Model (3) we analyze the case in which the peer informed subject knows s/he is behind the peer respectively in terms of effort choice and in terms of results. In Model (2) *bigger result* has a coefficient positive and strongly significant at 1% level for the base model and for the model estimated on female. Model (3) includes *bigger effort* which has a coefficient positive and slightly significant at 10% in the base model, and at 5% in model estimated for female only.

The models estimated in table 4 are similar. In all of them, the coefficient for *optimal1* is negative and highly significant at 0.1% level, reflecting the fact that having chosen optimally the initial effort has a strong negative impact on the probability of revising it. It takes value around 3.3, meaning that, for a subject who chooses optimally the initial effort (*optimal1*=1) compared to a subject who make a suboptimal initial choice, a decrease of about 3.3 is expected in the log odds of the dependent variable *diff*, holding constant all other variables.

The same is true for the coefficient of the variable *time22*, which is positive and highly significant at 0.1% level in all the models, indicating that the time spent in revising the initial choice has a positive

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Since we established that the content of information received is relevant in explaining individual behavior, in next section we will also concentrate on the content of the peer information.

[33] We choose a Logit model rather than a Probit, since the latter requires the assumption of normality distribution of the residuals. We estimated as a Probit model the same specification as in (5) and we performed several Normality tests which all reject the hypothesis of normal distribution of the residuals: Skewness and Kurtosis test p-value=0.000; Shapiro-Wilk W test, p-value =0.000.

[34] We tested other two specification of the model. The first included 15 dummies, one for each of the repetitions. The second included 3 dummies, one for 5 repetitions each. In both cases the dummies are never significant.

impact on the probability of revising it. Finally, the coefficient for the variable *rep2* is negative and significant at 5% level in all the models estimated on female.

Table 4. Logit for diff

	(1)	(1-female)	(2)	(2-female)	(3)	(3-female)
Const	.081282 (.4539363)	-.1244763 (.4075158)	.0048006 (.4445513)	-.1293912 (.4294604)	.1041283 (.4226729)	.1038828 (.4359879)
Optimal1	**-3.274299*** (.3210416)	**-3.157848*** (.383123)	**-3.210917*** (.3240847)	**-3.179135*** (.3807539)	**-3.306802*** (.3246708)	**-3.339824*** (.3522702)
Peer	.3104392 (.3432399)	.6645464 (.4147918)	-	-	-	-
Bigger result	-	-	**.9367254** (.3152326)	**1.163393** (.363506)	-	-
Bigger effort	-	-	-	-	**.6269176^** (.3292919)	**.9308473*** (.386624)
time1	**-.0158755^** (.0082554)	-.009738 (.0094405)	-.0134899 (.0082611)	-.0082237 (.0099856)	**-.0160366^** (.0084115)	.012114 (.0097471)
time2	**.0544882*** (.0128936)	**.0480817** (.0146885)	**.0526904*** (.0121428)	**.0474472** (.0139716)	**.054306*** (.0128406)	**-.049842** (.0147599)
Period	.0128605 (.0335751)	.0112046 (.0450808)	.012086 (.0341674)	.0152606 (.0461113)	.0145252 (.0336395)	.0199768 (.0438042)
Rep2	-.3769953 (.2798599)	**-.7008751*** (.3142529)	-.4060063 (.2583649)	**-.6773258*** (.2861033)	-.43151 (.2793823)	**-.7644751*** (.3223776)
Gender	-.2699486 (.3723863)	-	-.2800698 (.379888)	-	-.1950074 (.3777177)	-
Goodness of fit test						
N	1080	675	1080	675	1080	675
Wald chi2	(5) 197.34	(4) 128.24	(5)187.44	(4)120.73	(5)165.72	(4) 130.58
Prob > chi2	0.000	0.000	0.000	0.000	0.0000	0.0000
Pseudo R2	0.3580	0.3548	0.3735	0.3736	0.3623	0.3586
Log pseudolikelihood	-239.16636	-157.20302	-233.39946	-152.61796	-237.57369	-156.29082
N(obs)	1080	675.	1080	675	1080	675
N(groups)	10†	10†	10†	10†	10†	10†
Hosmer-Lemeshow chi2(2)	(8)11.10	(8)5.49	(8)4.43	(8)6.27	(8)4.33	(8)5.26
Prob > chi2	0.1963	0.7044	0.8166	0.6173	0.8264	0.7297

Std. Err. adjusted for 72 clusters in subject in Model (1), (2), (3). Std. Err. adjusted for 45 clusters in subject in Model (1-female), (2-female), (3-female). The level of significance is shown with the following notation: *** (.000) indicates a p-value of the t statistic lower than 0.1%, ** a p-value between 0.1% and 1%. * indicates a p-value higher than 1% and lower than 5%, ^ indicates a p-value higher than 5% and lower than 10%.

† Table collapsed on quantiles of estimated probabilities.

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[35] We estimated each of the models in Table 1 including other variables, as the dummies for type of subjects, the time spent in looking at the feedback screen, the fact that the same mp was repeated more than 3 times. The coefficients of these variables are never significant.

Given a difference of 8.348 in Bayesian Information Criterion (BIC), the goodness of fitness test provides very strong support for model (2) with respect to model (3) in fitting the data[36].

Focusing on model 2 we can calculate the predicted probability of revising the initial effort when subjects learn that the peer obtained higher result. For initial suboptimal choices, (*optimal1*=0), the probability of revision increases of about 22% (from 27.85% to 49.61,83%, at the 5% significance level) if peer information has such content rather than not (or if it is not provided). Similarly, given an initial optimal choice (*optimal1*=1), the probability of revising it increases of about 2.32% (from 1.53% to 3.82%, significant at 5%)[37].

Finally we can calculate how the model fits the data: the percentage of correctly classified observation is 90.46%. The false positive classification error ratio is 0.0291 of the cases (i.e. observations are misclassified as 1 when the correct classification is 0); while, the ratio of false negative error is much higher and equal to 0.6356 (values are misclassified as 0 when the correct value is 1)[38].

Finally, to check any possible endogeneity problem in our model we run a Sargan test. We regress the residual of model (2): *res2* on the sets of the explanatory variables, and then we look at F-value. F-value indicates the probability that the outcome -residuals in this case- is not explained by any variable but the constant. Indeed this is the case, and the Prob > F =0.9781.

Therefore we have provided support for this result: it is not sufficient to receive any peer information to observe peer effects: being informed that the peer is obtaining a higher result increases the probability of revision of the initial effort. In next section we will concentrate on the probability of revising the initial suboptimal choice such that the revised effort choice is optimal.

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[36] The test is reported in the appendix.

[37] We conducted several tests for assessing the goodness of fit of the model. We performed the Hosmer and Lemeshow's goodness-of-fit test for grouped data. The value of the Hosmer and Lemeshow's chi-square with 8 degrees of freedom is 4.43, with a p-value of 0.8166 which does not reveal any problem with the fit of the model. We also performed the Pearson goodness-of-fit test for the estimated model, which compares the observed against the expected number of responses using cells defined by the covariate patterns. The value of the Pearson chi-square with 1052 degrees of freedom is 1066.09, p value 0.3744. Since the number of covariate patterns approaches the number of observations, we preferred to use the Hosmer and Lemeshow's goodness of fit test.

[38] We perform a linktest to detect any specification error. The linktest is not significant (_hat is significant (p-value .000) while the variable _hatsq is not significant (p-value 0.689), therefore we can conclude that our model is correctly specified

Finally, to check any possible endogeneity problem in our model we run a Sargan test. We regress the residual of model (2): *res2* on the sets of the explanatory variables, and then we look at F-value. F-value indicates the probability that the outcome -residuals in this case- is not explained by any variable but the constant. Indeed this is the case, and the Prob > F =0.9781.

3.4.4 The optimal revision choice

In this section we analyze whether being exposed to peer information does increase the probability of revising optimally the initial choice. Despite the simplicity of the task the 60.4% of suboptimal initial choices are actually not revised. Moreover, if we consider the revised effort choices, only 50% are optimal, consequently the 18,15% of the total choices are suboptimal even after the revision stage.

In this situation, we evidence that peer effects increases the probability of optimal revision, as reported in Result 2.

Result 2

Learning that the peer is obtaining an higher result increases the probability of revising optimally the initial (suboptimal) choice.

Support for this result comes from table 5.

Table 5 contains the numbers of suboptimal (initial) effort choice which have been optimal revised.

Table 5. optimal revision choices by treatment

	Peer Treatment	Control treatment	A_lp	Other	Total
% of optimal revisions	24.53	17.78	32.69	17.36	39.61
Std. dev					

A t-test evidences that the percentage of optimal revision is significantly higher in peer treatment: p-value 0.0154, however, no significant differences are evidenced for the revision which are not optimal t-test, p-value 0.2533 (second mistakes in the revision phase are statistically not more frequent for those subjects exposed to peer information). The results are confirmed by a Mann Whitney test.

To analyze how information about peer affects the probability of revising optimally the initial (suboptimal) effort choice we estimate the following Logit model[39]:

$$\text{Logit(diff=1)} = \Lambda(\gamma_0 + + \gamma_1 peer + \gamma_2 time11 + \gamma_3 time22 + \gamma_4 period + \gamma_5 gender + \gamma_6 profit1) \quad (6)$$
$$\text{if rational1} = 0$$

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[39] The same results are obtained if we estimate the model on the subset of revision choices or on the whole numbers of choices. These result are obtainable upon request.

The result are reported in Table 6, where model 2 and model 3 are identical to model (1) but for the definition of peer effect used.

The only definition of peer effect significant is associated to the dummy bigger result. Therefore, knowing that the other is obtaining a higher result has a determinant effect on inducing the subject of revising the initial choices optimally.

Table 6 Logit for diff if optimal1==0

	(1)	(2)	(3)
Const	.569035	.337017	.8633859
	(.9044415)	(.8420689)	(.8337533)
Peer	3540451	-	-
	(.3819712)		
Bigger result	-	**8374572****	-
		(.3316326)	
Bigger effort	-	-	4397377
			(.3455589)
time2	-.0010603	.0088747	-.0038253
	(.0254518)	(.0252935)	(.0242956)
Period	-.035274	.-.0423134	-.0323142
	(.0375561)	(.039312)	(.0359033)
Rep2	**-.2065895**	**-.20706^**	-.2046004
	(.112288)^	**(.1094555)**	(.1123248)
Gender	.1814761	.154209	.0934703
	(.3637909)	(.3559898)	(.348811)
Profit	**-.0348288***	**-.0313306***	-.0370227*
	(.0159159)	**(.0150325)**	(.016236)
N	255	255	255
Wald chi2	(6) 12.41	(6)21.87	(6)12.43
Prob > chi2	0.0534	0.0013	0.0531
Pseudo R2	0.0493	0.0673	0.0498
Log pseudolikelihood	-162.76763	-159.6876	-162.67642
N(groups)	10+	10+	10+
Hosmer-Lemeshow	(8)0.6789	(8)3.05	(8)4.33
Prob > chi2	0.6789	0.9309	0.8264

Std. Err. Adjusted for 59 clusters in subject in Model (1), (2), (3). The level of significance is shown with the following notation: *** (.000) indicates a p-value of the t statistic lower than 0.1%, ** a p-value between 0.1% and 1%. * indicates a p-value higher than 1% and lower than 5%, ^ indicates a p-value higher than 5% and lower than 10%.

+ Table collapsed on quantiles of estimated probabilities.

The percentage of observations correctly classified by model (2) is 61.34%. Also in this case, the channel through which peer information is taken in account by subjects refers to the case in which it contains negative feedback about the result. We can calculate the predicted probability of revising optimally the initial choice for different profiles. For a female not receiving any peer information the

predicted probability of revising optimally the initial choice is around 43.5%, while if she receives peer information "a_lp" it increases of about 28% and it becomes 71.3%.

For a male without peer information the probability of optimal revision is around 46.7% ant it increases at 73.7% if peer information as described by "a_lp" is provided[40].

3.5   Discussion

Peer pressure seems to raise productivity under fixed wages but not necessarily under different incentive schemes. We investigate the role of peer pressure through peer information when subjects have to perform a simple decision making task which is incentivized in such way each subject's choice is independent from the other participants' choices. This design recalls piece rate, the simplest incentive scheme adopted in may organizations.[…]

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[40] In order to check whether a problem of Endogeneity affects our model, we can regress the residual of model (13): (res4) on the sets of the explicative variables. If we do not have Endogeneity, we expect that none of the coefficients of the independent variable is significant. Indeed this is the case.

The link test excludes any specification error. The variable "hat" is significant at 1% level of confidence (p-value: 0.005), while the "hat_sq" coefficient is not statistically significant, so we accept the null hypothesis that the model is correctly specified. In order to test the goodness of fit, in addition to the Hosmer and Lemeshow's test, and the calculation of the % of correctly classified observations, we run the lfit test: we accept the null hypothesis that the model is well specified: p-value 0.3459. The test for collinearity reported below, exclude any problem of multicollinearity among the independent variables.

References

1. Bewley, T., 1999. *Why wages don't fall in a recession.* Cambridge: Harvard University Press.

2. Clark, A.E., Senik, C., 2009. Who compares to whom? The anatomy of income comparisons in Europe. IZA Discussion Paper No. 4414, Institute for the Future of Labor, Bonn.

3. Falk, A., Ichino A., (2006), Clean Evidence on Peer Effects, "Clean Evidence on Peer Effects." Journal of Labor Economics, 24(1): 39–57.

4. Fischbacher, Urs. 2007. z-Tree: Zurich toolbox for readymade economic experiments. *Experimental Economics* 10 no. 171-178.

5. Gächter S., Nosenzo D., Sefton, M., 2008. The Impact of Social Comparisons on Reciprocity, Discussion Papers 2008-09, The Centre for Decision Research and Experimental Economics, School of Economics, University of Nottingham.

6. Gächter, S., Töni C., 2010, Social Comparison and Performance: Experimental Evidence on the Fair Wage-Effort Hypothesis, IZA Discussion Paper No. 4687, Institute for the Future of Labor, Bonn.

7. Kandel, E., Lazear, E.P., (1992), "Peer Pressure and Partnerships", Journal of Political Economy, 100(4): 801–17.

8. Manski, C. (1993). Identification of Endogenous Social Effects: The Reflection Problem. *Review of Economic Studies*, 60, 531–542.

9. Mas A., Moretti, E., (2009), Peers at Work, American Economic Review 2009, 99(1), 112–145.

10. Sausgruber, R., (2009). "A note on peer effects between teams," Experimental Economics, Springer, vol. 12(2):193-201.

11. Suls, J., Martin, R., & Wheeler, L. (2002). Social Comparison: Why, with whom and with what effect? *Current Directions in Psychological Science*, 11(5), 159-163.

Appendix A.

Table A1. *LOGIT estimations for Diff.*

	(2)	(2-female)	(3)	(3-female)	(4)	(4-female)
Const	.038475 (.4482044)	-.1461975 (.4056751)	.0762001 (.4260846)	-.0427604 (.397733)	.2159641 (.409135)	.2064171 (.4094858)
Optimal1	**-3.227318*** (.3100803)	**-3.110513*** .374184	**-3.287961*** (.3292324)	**-3.239769*** (.3930347)	**-3.300081*** (.3319032)	**-3.178508*** (.3607601)
Different result	.4174707 (.3323956)	**.6849036^** (.3995653)	-	-	-	-
Different effort	-	-	.4609893 (.3093014)	**.7045065** (.3821976^)	-	-
Lower effort	-	-		-	.0296113 (.3727617)	.1337713 (.4338729)
time1	**-.0154159^** (.0081861)	-.009544 (.009521)	**-.0162137*** (.0081376)	-.0427604 (.397733)	**-.0168211*** (.0084147)	-.0120649 (.0097062)
time2	**.053523*** (.0129861)	**.047236**** (.0149557)	**.0538126*** (.0129032)	**.0478105**** (.014889)	**.0551933*** (.0130879)	**.0489872**** (.014942)
Period	.0121687 (.0338259)	.0112275 (.0453161)	.0141544 (.0334498)	.016194 (.0435796)	.0137791 (.0333378)	.0133943 (.0433754)
Rep2	-.3767481 (.2797798)	**-.6869047*** (.312798)	-.4157073 (.2825699)	**-.7612862*** (.3327718)	-.3710506 (.2771802)	**-.6931911*** (.3015318)
Gender	-.2894337 (.3736534)	-	-.2739877 (.372058)	-	-.2390495 (.3732774)	-
N	1080	675	1080	675	1080	675
Wald chi2 Prob > chi2 Pseudo R2 Log pseudolikelihood	(5) 186.79 0.000 0.3598- 238.51355	(4) 124.65 0.000 0.3557 -156.99986	(5)183.06 0.000 0.3608 -238.15779	(4) 116.60 0.000 0.3568 -156.71772	(5) 204.47 0.0000 0.355 8-239.98904	(4) 162.71 0.0000 0.3452 -159.56055
N(obs)	1080	675	1080	675	1080	675
N(groups)	10+	10+	10+	10+	10+	10+
Hosmer–Lemeshow chi2(2) Prob > chi2	(8)13.05 0.1100	(8)6.17 0.6286	(8)9.93 0.2699	(8)3.23 0.9193	(8)6.27 0.6173	(8)2.93 0.9384

The level of significance is shown with the following notation: *** (.000) indicates a p-value of the t statistic lower than 0.1%, ** a p-value between 0.1% and 1%. * indicates a p-value higher than 1% and lower than 5%, ^ indicates a p-value higher than 5% and lower than 10%.

+ Table collapsed on quantiles of estimated probabilities. Std. Err. adjusted for 72 clusters in subject in Model (1), (2), (3). Std. Err. adjusted for 45 clusters in subject in Model (1-female), (2-female), (3-female), (4-female), (5-female) and (6-female).

Table 18 Logit estimation for Diffr

	(8)	(9)	(10)	(11)
Const	-1.035948 (.7189227)	-1.109534 (.7255847)	-1.107914 (.745398)	-.6535163 (.6979418)
Typ_peer	**.6065898^** **(.3680417)**	-	-	-
Different effort	-	.6790518 (.4475051)	-	-
Different result	-	-	.6124573 (.4287851)	-
Lower effort	-	-	-	-.1616139 (.5145703)
Gender	.1452761 (.3440057)	.2071243 (.3446909)	.1964648 (.3466221)	.0532089 (.3606453)
Period	**.0750123^** **(.0446906)**	**.0806801^** **(.0457884)**	**.0833768^** **(.0462528)**	**.0815618^** **(.0430587)**
N	119	119	119	119
Wald chi2	(3) 4.97	(3) 4.47	(3)4.16	(3) 3.83
Prob > chi2	0.1742 0.0382	0.2150	0.2445	0.2803
Pseudo R2		0.0397	0.0370	0.0232
Log pseudolikelihood	-79.329532	-80.960369	-79.428662	-80.567063
Goodness-of-fit test				
N(obs) N(groups) Hosmer-Lemeshow chi2(2) Prob > chi2	119 10⁺ 4.59 0.8006	119 10⁺ 6.06 0.6407	119 10⁺ 6.54 0.5868	119 10 6.07 0.6394

The level of significance is shown with the following notation: *** indicates a p-value of the t statistic lower than 1%, ** a p-value between 5% and 1%. * indicates a p-value higher than 5% and lower than 10%.

§ Dropped because of collinearity

+ Table collapsed on quantiles of estimated probabilities)

++ There are only 3 distinct quantiles because of ties)

Appendix B- Instruction

The experiment has been conducted in Italian. Below the translation of instructions that each participants received on her/his screen.

Now we start the first activity.

First we will explain to you the decision frame. At the end of these instructions you will find some control questions which will help you in gaining a better understanding of the decision frame. If you have any question at any time, please rise your hand and one of the assistant will come at your desk to answer.

This activity will be repeated **15 times**.
All repetitions are identical. Only **one** repetition will be relevant for your final payment. At the end of the 15 repetition the computer will select 1 repetition randomly. For each participant, the randomly selected repetition will be used in order to determine the number of points which will be converted in Euro at the exchange rate o 1 pint= 0.2€ . You will receive money at the end of the experiment.

Ripetizione

| 1 di 1 | Tempo rimanente [sec]: 297 |

Ora inizieremo la PRIMA ATTIVITA'

Per prima cosa ti spiegheremo la situazione decisionale.
Alla fine di queste istruzioni toverai delle domande di verifica che ti aiuteranno ad acquisire padronanza con la situazione decisionale.
Se hai delle domande, in qualunque momento, ti preghiamo di alzare la mano e uno degli assistenti verrà al tuo posto per rispondere.

Questa prima attività contiene **15 ripetizioni.**
Tutte le ripetizioni sono identiche. Solo **UNA** ripetizione sarà rilevante per il tuo pagamento.
Al termine delle 15 ripetizioni il computer ne selezionerà 1 in maniera casuale.
Per ogni partecipante, la ripetizione selezionata sarà utilizzata per determinare
il numero dei punti che dovranno essere convertiti in euro al tasso di cambio di **0.2 Euro** .
I pagamenti in denaro saranno effettuati alla fine dell'intero esperimento.

Activity 1.

This activity will be repeated **15 times**.

In each repetition you have to choose a number between 0 and 10 (extremes included).

The number you choose will be multiplied by **a multiplicative factor FM**. At the beginning of each repetition the multiplicative factor will appear on your screen.

For each of the number that you cha choose, a cost is associated. The greatest the number you choose the greatest the associated cost. The cost of the number you choose in NOT influenced by the multiplicative factor MP.

In every repetition, your result in point will be calculated as follow:

RESULT=(chosen number)x (FM)-(cost of the chosen number)

This table contains an example. Let' assume that the multiplicative factor is 5.

Ripetizione

| 1 di 1 | Tempo rimanente [sec]: 298 |

Attività 1

Questa attività sarà ripetuta **15 volte**.
In ogni ripetizione devi scegliere un numero da 0 a 10 (inclusi).
Il numero scelto sarà moltiplicato per un **fattore di moltiplicazione (FM).** All'inizio di ogni ripetizione il fattore di moltiplicazione apparirà sullo schermo.
Ad ogni numero che puoi scegliere è associato un costo. Più grande è il numero che scegli, maggiore è il costo associato.
Il costo del numero NON è influenzato dal fattore moltiplicativo FM.

In ogni ripetizione il tuo risultato in punti, sarà determinato in questo modo:
RISULTATO = (numero scelto) x (FM) -(costo del numero scelto)

Questa tavola contiene un **esempio**. Ipotizziamo che il fattore moltiplicativo FM sia **5.**

Numero	Numero x FM	Costo
0	0	0
1	5	0.5
2	10	2
3	15	4.5
4	20	8
5	25	12.5
6	30	18
7	35	24.5
8	40	32
9	45	40.5
10	50	50

Let's summarize:

RESULT=(chosen number)x (FM)-(cost of the chosen number)

Example 1

The table you see in the screen is an example made assuming that the multiplicative factor is 3.

In every repetition you will see a table as this in your screen. It contains:

-In the **FIRST COLUMN**: the number you can choose, from 0 to 10;

-In the **SECOND COLUMN** the numbers from the first column multiplied by the multiplicative factor that has been selected (in this case 3);

-In the **THIRD COLUMN**: the cost associated to each number.

Ripetizione

1   di   1

Tempo rimanente [sec]:   296

Ricapitoliamo:
RISULTATO = (numero scelto) x (FM) -(costo del numero scelto)

ESEMPIO 1
La tavola che vedi nello schermo continene un **esempio** Ipotizza che il Fattore Moltiplicativo sia **3.**

In ogni ripetizione sul tuo schermo vedrai una tavola come questa. Essa contiene:
- nella **PRIMA COLONNA** : i numeri che puoi scegliere;

- nella **SECONDA COLONNA** i numeri moltiplicati per il fattore moltiplicativo selezionato
(in questo esempio tutti i numeri sono moltipicati per 3);

-nella **TERZA COLONNA** il costo associato ad ogni numero.

Numero	Numero x FM	Costo
0	0	0
1	3	0.5
2	6	2
3	9	4.5
4	12	8
5	15	12.5
6	18	18
7	21	24.5
8	24	32
9	27	40.5
10	30	50

Let's continue with the previous example (FM=3)

If we choose number 4, our result will be:

RESULT=(chosen number)x (FM)-(cost of the chosen number)

(4x3)-8=8 points

If we choose number 6, our result will be:

RESULT=(chosen number)x (FM)-(cost of the chosen number)

(6x3)-18=0 points

PAY ATTENTION. In some cases it is possible to obtain negative or null result.

However, you can always make your choices in order to avoid null or negative results.

Ripetizione

1 di 1

Tempo rimanente [sec]: 293

Continuiamo con l'esempio precedente **(FM=3)**

Se scegliamo il numero 4 il nostro risultato sarà:

RISULTATO= (numero scelto x FM) -costo del numero

(4x3)-8= 4 punti

Se scegliamo il numero 6 il nostro risultato sarà:

(6x3)-18= 0 punti

ATTENZIONE. In alcuni casi è possibile realizzare risultati nulli o negativi.

Ma potete **SEMPRE** fare le vostre scelte in modo da **evitare risultati nulli o negativi**

Numero	Numero x FM	Costo
0	0	0
1	3	0.5
2	6	2
3	9	4.5
4	12	8
5	15	12.5
6	18	18
7	21	24.5
8	24	32
9	27	40.5
10	30	50

Chapter 4

Do not trash the Incentive!
Monetary Incentives and Waste Sorting[41]

CHAPTER PREVIEW: This paper sheds new light on the effectiveness of monetary incentives. We analyze incentives aimed to encourage solid waste differentiation in the 95 municipalities of the district of Treviso (Italy) during the period 1999-2008. Our dataset is unique for three reasons. First, in our sample the incentive mechanism is randomly assigned to the municipalities. Second, our data show wide heterogeneity of policies over the years. Third, its panel structure allows us to control for potential increasing concern for the environment, and to isolate potential "learning effects" of incentives over time. We find that the introduction of economic incentives has a significant and positive net effect of around 12% on the recycling waste ratio, that is complementary to the positive effect induced by door-to-door collection. The effect of PAYT is obtained by increasing the production of sorted waste (+10%), while the production of total waste remains unchanged. We therefore conclude that economic incentives are an effective tool to reach the desired goal.

4.1   Introduction

In many ways economics is the study of incentives and their optimal design. An incentive is anything (monetary or non-monetary) that enables or motivates a person to undertake a particular action, or choose an alternative instead of another. An incentive changes the relative cost of the available options in favor of the desired one. Incentives are widely used in the workplace, to align employees' and organization's goals, but also in many other contexts and with many different applications. For instance, incentives may be used to promote healthy habits like attending an exercise facility (Charness and Gneezy, 2009) or safe driving (Dionne et al., 2010). Incentives are used also to reduce harmful behavior such as smoking cigarettes (Gruber and Köszegi, 2001), alcohol consumption (Cook and Tauchen, 1982) and junk food eating (Jacobson and Brownell, 2000).

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[41] Some Section of this chapter will be part of the paper *"Do not trash the Incentive! Monetary Incentives and Waste Sorting"* joint with Alessandro Bucciol (University of Verona) and Marco Piovesan (Harvard Business School).

However, recent economic literature reports evidence from field and laboratory experiments that incentives may be ineffective (Angrist and Lavy, 2009) or they may even produce detrimental effects, undesired results and crowding-out of intrinsic motivation (see for instance, Ariely et al., 2009; Frey and Oberholzer-Gee, 1997; Gneezy and Rustichini, 2000). Bénabou and Tirole (2003) motivate these findings with a principal-agent model, and they and establish that the effect of incentives is negative if the agent cares about the principal's beliefs and positive otherwise. This is because if the principal asks for high effort, the agent may think that the principal has a bad opinion of her. In light of these recent results, the effectiveness of incentives no longer seems trivial and deserves to be carefully analyzed: incentives may substitute intrinsic motivations but may also reinforce them, resulting in an additive effect, Bowles (2010), Galbiati and Vetrova (2009).

Our goal is to study the effectiveness of economic incentives in a controversial environment: domestic waste disposal. Every day we produce enormous amount of solid waste that we must eliminate somehow. Options include burying waste in landfills or burning it in incinerators. However, landfills may store only a small part of our waste, and they often find resistance in local communities (Kinnaman and Fullerton, 2000); incinerators are expensive and their consequences on health and the environment seem controversial (see British Society for Ecological Medicine, 2005 and Health Protection Agency, 2005). The best solution seems to sort domestic waste, which will then be recycled. At the moment this process is the simplest, least expensive and most environment-friendly way of treating waste. However, sorting waste is not a pleasant activity: it requires considerable effort, a lot of time and attention. For this reason, throughout the world we observe a trend to adopt incentives for increasing the percentage of sorted to total waste (the so called "recycling waste ratio").

Historically, households in western countries used to drop off all their mixed waste in special bins placed along the streets, and they were charged a flat fee related to parameters such as the house size and/or the number of household components. Local administrators progressively started promoting increasingly more accurate collections of sorted waste in the streets. More recently, some municipalities chose to collect waste door-to-door (DtD). DtD made the collection of sorted waste easier and cheaper for the users, who sort waste at home and do not need to carry it and drop it off along the streets. For this reason, DtD induces a non-monetary incentive to sort waste. In the latest few years, a growing number of local administrators gave up the flat fee and started adopting a per-unit pricing, the so called "pay-as-you-throw" (PAYT) pricing. This pricing system is designed to encourage waste sorting through monetary incentives, since it links fees to the amount of actual residual (unsorted) waste produced. PAYT is usually combined with a DtD collection program to

properly measure the amount of waste produced by each user (Kinnaman and Fullerton, 2000). Previous estimates found that the recycling waste ratio increases by 25%-35% with the joint adoption of DtD and PAYT (see Miranda et.al. 1994, Allers and Hoene, 2010, and the literature review in Kinnaman, 2006).

Our study makes a step forward and aims to disentangle the net effect of PAYT monetary incentives from the effect of DtD non-monetary incentives. In fact, for the reasons discussed above, a priori it is not clear whether the economic incentive works properly (that is, it has a positive impact on the recycling ratio), it is not well designed (it has no effect) or it crowds out intrinsic motivations (it has a negative impact). Our analysis thus provides decision makers with insights on the effectiveness of monetary incentives on recycling behavior. From a broader perspective, our paper aims to contribute to the debate on the effectiveness of economic incentives (as induced by PAYT) in aligning individual and public interests to produce beneficial effects for the society.

We focus on waste disposal over the period 1999-2008 of the 95 municipalities of the district of Treviso (Italy). These municipalities show an outstanding recycling ratio of municipal solid waste, placing them among the top practices in Italy and in Europe. The average recycling ratio for the whole district in 2008 was 68.5%, with nearly half the municipalities achieving a ratio higher than 75% and a peak of 84.4%; in contrast the national average for 2008 was 30.6% (Arpav, 2009). These results are astonishing if compared with the average recycling ratio for the district in 1998 (30%; Arpav, 2000). Apparently, the adoption of a new governance for waste management made this performance possible.

Our dataset has three main advantages. First, prior to the period we consider, a regional law divided the district in three geographical areas, each one managed by a different consortium for waste management. Therefore, municipalities in our sample are not directly responsible for the decisions on waste management, but they just follow the prescriptions of the consortia. This removes potential endogeneity problems, since towns that are more active in environmental issues might want to choose incentive-based collection and payment schemes. Second, the sample includes wide heterogeneity of policies; 94 of the 95 towns in 1999 were adopting drop-off collection and flat fee pricing, while in 2008 41 were adopting DtD and flat fee pricing, and 53 DtD and PAYT pricing. Third, the panel structure of our data allows us to control for exogenous features as an increasing concern for the environment, and to isolate potential "learning effects" of incentives over the years.

Our result supports the view that well-designed economic incentives are effective. Indeed, we find that the adoption of PAYT has a significantly positive net effect of increasing the recycling ratio by

around 12.2% which adds to the positive effect of DtD collection system (18.1%). This suggests that the economic incentive brought by PAYT is complementary to the non-economic incentive brought by DtD. This result of PAYT is obtained by increasing the production of sorted waste (+9.6%), while the production of total waste remains unchanged. In addition, we find evidence of a "learning effect" of incentives, since the recycling ratio increases by a further 1.8% every additional year a PAYT program is active, and a "emulation effect", since it increases by a further 3.7% for any confining municipality implementing PAYT. Our findings thus confirm that monetary incentives, when properly designed and well targeted, are an effective way to induce the desired behavior and reinforce intrinsic motivation.

The remainder of the paper is organized as follows. Section 2 describes the data source and the characteristics of the municipalities in our dataset. Section 3 describes our econometric model and presents our main findings. Section 4 concludes discussing some open questions and presenting the direction of our future research. Two final appendices provide further details on waste management in our dataset

4.2   Data

We collected data between 1999 and 2008 on the amount of waste produced in a given year in the municipalities of the small but highly populated district of Treviso (North-Eastern Italy).[42] This gives us a total of 10 annual time series observations for each of the 95 municipalities in the district.[43] Over the last decades the municipalities in this district showed outstanding progress in terms of sorted solid waste collection, moving from an average recycling ratio (the ratio between the amount of sorted waste and total waste) of 35.4% in 1999 to a ratio of 68.5% in 2008 (Arpav, 2000, 2009). The recycling ratio in 2008 was outstanding compared with the national average (30.6%) and the regional average (53.9%). Many of these municipalities are among the best practices in waste management in Italy (Legambiente, 2009) as well as Europe, exceeding by far the targets of differentiation set by the

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[42] The district covers an area of 2,477 square kilometers with an average of 355 inhabitants per square kilometer.

[43] We ignore data before 1999 as municipalities were still in the process to organize their waste management and therefore the quality and reliability of the data was rather poor.

European Commission (Eurostat, 2010). This success is possibly due to the change in waste management policies arisen over our sample period.

The building blocks of our data are two: first, yearly data on sorted and residual waste production at municipal level provided by the Regional Agency for Environmental Prevention and Protection of Veneto (ARPAV)[44]; second, raw data on demographic characteristics of each municipality, provided by the Italian National Institute of Statistics (ISTAT), and further elaborated by the statistical unit of the Veneto Region.

As described in Appendix A, a regional law created between the late 80s and the early 90s three geographical areas within the district and encouraged the creation of independent consortia of municipalities within each area. As of 2008, 91 municipalities out of 95 adhered to the consortium operating in their area (the names of the consortia are Priula, Savno and TV3). Four municipalities chose not to belong to a consortium for structural or geographical reasons[45].

After joining a consortium, each municipality delegates decisions on waste management to the consortium board. The boards of the three consortia implemented different policies over the period under our investigation. In particular, our sample includes municipalities choosing different collecting and pricing systems (see Appendix B for more details). This variation over time creates unique heterogeneity in the data, which we exploit to disentangle the effect of the introduction of door-to-door (DtD, as opposed to drop-off) collection from the effect of pay-as-you-throw (PAYT, as opposed to flat fee) pricing and therefore, estimate the net effect of monetary incentives on recycling.

The two alternative pricing formulas work as follows. The flat fee is proportional to the user's house surface and/or the number of household members:

$$\textit{flat fee} = \phi_0 \times \left(\# \textit{house square meters} \right) + \phi_1 \times \left(\# \textit{household members} \right) \qquad (1)$$

where ϕ_0 and ϕ_1 are respectively the cost per square meter and per household member. In this system there is no direct link between the actual waste production and the fee paid, even though "# house square meters" and "# household members" are reasonable proxies for the production of waste.

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[44] Information about ARPAV may be found at http://www.arpa.veneto.it/inglese/htm/chi_e_arpav.asp. We double-checked these data with those available to the consortia.

[45] Structural limits prevent Colle Umberto, Tarzo and Treviso from choosing freely a waste management system. Moreover, Mogliano Veneto replicates the waste system of the near municipalities in the district of Venice. The systems we observe may thus be interpreted as exogenous. In a separate robustness check, available upon request, we however repeated our analysis without these four municipalities. Our main findings are confirmed.

However, given a particular house and family size, there is no incentive to encourage sorting behavior.

In contrast, the PAYT's main feature consists in establishing a direct link between costs and users' sorting behavior. Many PAYT schemes are made of a fixed part identical for each single user, and a variable part which depends on the volume of the residual waste produced:

$$PAYT = \theta_0 + \theta_1 \times \left(\# emptyings\ of\ residual\ waste\ bin \right) \qquad (2)$$

where θ_0 and θ_1 are respectively the fixed cost and the cost per emptying of residual waste bin. According to this formula, accumulating residual waste is relatively costlier than accumulating sorted waste. In addition, in order to prevent users from sorting inappropriately and lowering the amount of unsorted waste, a system of monitoring and sanctioning is usually applied[46].

Figure 1 shows the dynamics of pricing system and collection methodology in our dataset. In 1999, 94 out of 95 municipalities in the district were implementing drop-off collection systems with flat fee pricing (one municipality, Vedelago, was instead implementing DtD with a flat fee). Since 2000, they gradually started changing policy; as of 2008, 41 out of 95 municipalities were implementing DtD with flat fee pricing, 53 were implementing DtD with PAYT pricing, and just 1 municipality (Treviso) was still adopting drop-off with flat fee pricing.

Figure 1. Dynamics of policy management. Municipalities implementing a given policy (%)

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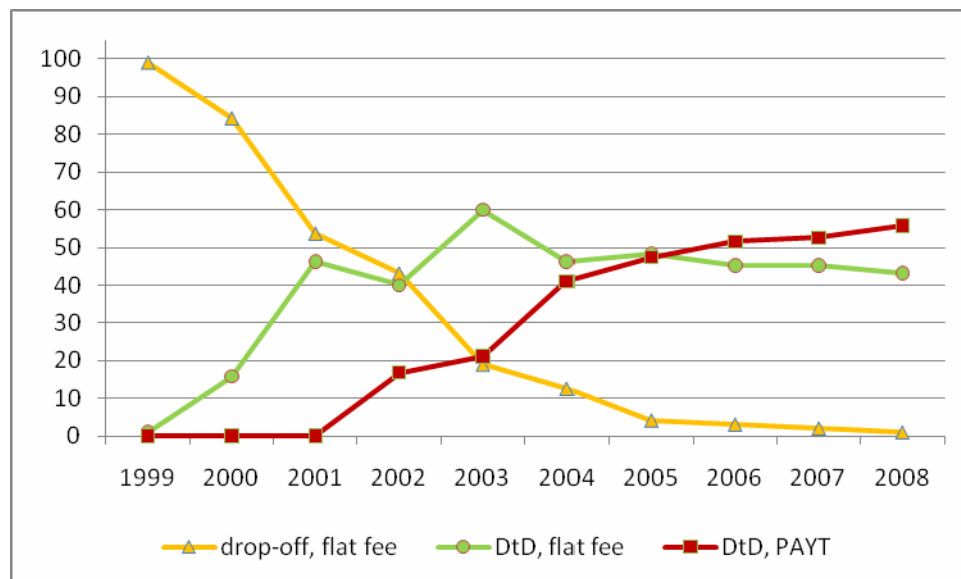
[46] The system in the district operates jointly with the local municipal authorities. In 2004, over 2,000 inspections have been conducted in the district of Treviso.

Hence, our dataset includes municipalities with three types of waste management system: drop-off with flat fee, DtD with flat fee, and DtD with PAYT. We observe no municipalities implementing drop-off and PAYT. In fact, systems with drop-off and PAYT are rarely seen in the world (see Reschovsky and Stone, 1994 and Kinnaman, 2006), as they make it extremely difficult to detect users' incorrect behavior. Appendix B reports more details on the historical evolution of pricing and collection systems in the district.

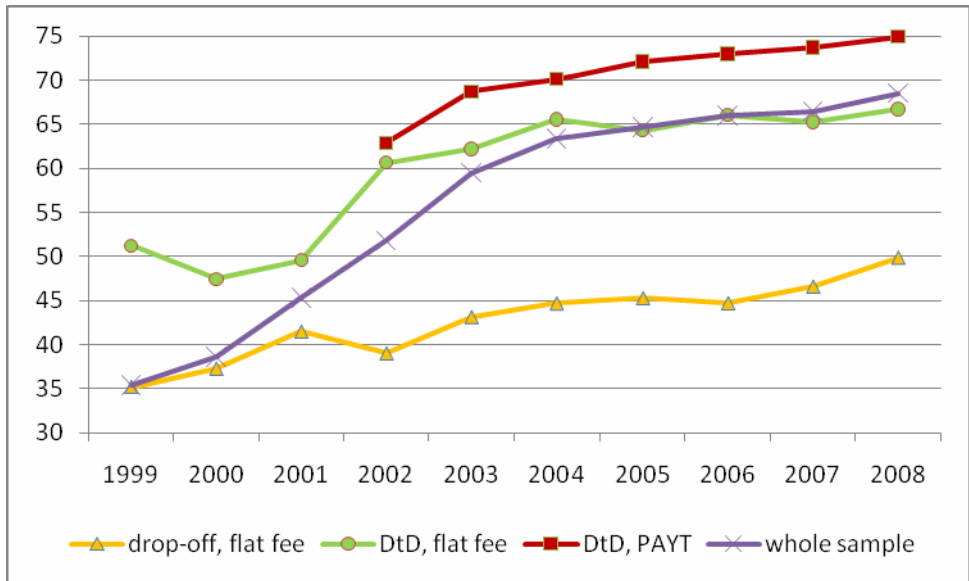**Figure 2.** Dynamics of the recycling waste ratio

Figure 2 shows the dynamics of the recycling ratio in our sample. We observe an increasing trend in the recycling ratio with all the waste management systems, even the one with no incentives at all (that is, the one with drop-off collection and flat fee).

The ratio is however steadily higher in the sub-sample of municipalities with DtD and PAYT. The analysis we perform in Section 3 aims to understand whether this differential in the recycling ratio is driven, at least in part, by PAYT incentives.

4.3 Result

In this Section we describe the estimation method, and we report the main results of our analysis. Our goal is to verify *i)* whether the introduction of an economic incentive (PAYT) has relevant effect at the municipal level, and *ii)* whether this effect adds up to the one associated with the DtD program, or instead it substitutes it. In particular, Sub-section 3.1 focuses on the econometric model and the variables we take into account; Sub-sections 3.2 and 3.3 discuss our findings.

4.3.1 Estimation method

The benchmark analysis is based on the following model, where i denotes the municipality and t time:

$$Y_{it} = \beta_0 + P_{it}'\beta_1 + C_{it}'\beta_2 + D_{it}'\beta_3 + T_{it}'\beta_4 + \mu_i + \varepsilon_{it} \qquad (3)$$

with $\left(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4\right)$ coefficients to be estimated, μ_i municipality effects and ε_{it} the error term. The dependent variable Y_{it} is the logarithm of the recycling waste ratio (the ratio between sorted and total waste) in Section 3.2, and the logarithm of per capita (sorted, total) waste in kilograms in Section 3.3. The benchmark specification includes explanatory variables that can be grouped in four sets, $\left(P_{it}, C_{it}, D_{it}, T_{it}\right)$. Below we describe the variables and why we take them into account. Table 1 reports descriptive statistics of the key variables in the dataset.

Policy variables

Set P_{it} includes variables on the waste management policy. We consider the dummy variable "PAYT" equal to 1 when the municipality is implementing PAYT, and the dummy variable "DtD" equal to 1 when the municipality is implementing DtD. The two variables capture the net effect of having either policy active. In particular, we are interested in the coefficient on PAYT. If it is significantly positive, then the economic incentive represented by PAYT is complementary to the non-economic one represented by DtD. If the coefficient is not significant, then the economic incentive is poorly designed. Finally, if it is significantly negative, then the economic incentive brought by PAYT is actually detrimental and it goes against the non-economic incentive represented by DtD.

Table 1. Descriptive statistics: average values

Variables	Median	Average	Std. Dev.	Minimum	Maximum
Recycling ratio (%)	63.105	58.981	15.399	6.125	84.400
Total waste (tons.)	1,992.693	3,341.758	5,249.893	298.858	50,244.365
Total waste per capita (kgs.)	328.665	338.938	74.376	171.418	611.201
Residual waste per capita (kgs.)	125.908	140.341	68.578	48.624	440.109
Sorted waste per capita (kgs.)	203.533	198.597	64.564	23.117	385.735
Year of PAYT implementation	2004	2003.867	1.662	2002	2008
PAYT	0	0.286	0.452	0	1
Years of PAYT	0	0.668	1.425	0	6
Year of DtD implementation	2002	2002.096	1.914	1994	2008
DtD	1	0.678	0.468	0	1
Years of DtD	1	2.187	2.478	0	14
N. confining towns with PAYT	0	1.637	2.127	0	9
N. confining towns with DtD	4	3.438	2.297	0	9
N. confining towns without DtD	1	1.699	2.091	0	9
N. inhabitants	6,227	8,693.527	10,028	702	83,971
% children aged 14 or younger	15.174	15.294	1.820	10.646	24.700
% adults aged 65 or older	17.426	17.384	2.885	10.170	25.220
% non-native residents	6.930	7.429	3.817	0.827	20.052
% district unemployment rate	3.400	3.320	0.573	2.500	4.100

950 observations; 95 municipalities

In addition, we include variables capturing a potential "learning process" in the application of PAYT or DtD policies. What we mean is that users may need time in order to become acquainted with the incentive scheme in the PAYT payment formula, or with the proper use of the different waste bins brought by DtD. Ignoring this might be misleading, and bias our estimates. We assume that this learning process follows a linear trend[47], and we create the corresponding variables as follows. If a PAYT program started in year t^*, the trend variable for PAYT at year t is defined as $\max\left\{0, PAYT \times \left(t - t^*\right)\right\}$. An equivalent definition applies for DtD. Thus each variable captures the effect of having a PAYT or DtD program active for one additional year.

Control variables

Set C_{it} includes control variables capturing potential "emulation" effects of confining municipalities (the number of confining municipalities implementing PAYT, the number of confining municipalities implementing DtD), and one variable capturing potential "hiding" effects (the number of confining municipalities not implementing DtD, interacted with the dummy variable on PAYT).

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[47] We treat a linear trend because PAYT and DtD programs in our sample have all started since few years, and for this reason we could not be able to capture further degree polynomials.

We treat these variables for the following two reasons. First, households may be more willing to sort waste if they see that their peers in neighbor municipalities already do this ("emulation" effect). Second, households living in municipalities following a PAYT program may choose to avoid their duties and throw waste in near municipalities that are still under a program with drop-off collection ("hiding" effect). Illegal dumping is indeed one of the main concerns when introducing PAYT (see Fullerton and Kinnaman, 1996).

Demographic variables

Set D_{it} includes variables on the demographic composition of the municipality: the logarithm of the number of inhabitants, the percentage in the population of children aged 14 or younger, the percentage in the population of individuals aged 65 or older, and the percentage in the population of non-native residents.

The reason to include these variables is as follows. First, the number of inhabitants informs on the size of the municipality and how it evolves over the years. We expect that larger municipalities with more inhabitants are structurally different than smaller municipalities with fewer inhabitants, which should have implications on the effectiveness of changing the recycling ratio. Second, we expect the recycling ratio to change in municipalities with a higher percentage of young people (who are often the target of media campaigns on environmental issues) and elder people (who usually do not work and have more time to sort waste efficiently). Finally, we may expect that non-native residents are more reluctant than native ones to follow the prescriptions of PAYT and DtD programs, for several reasons (culture, language, etc.).

Time variables

Set T_{it} includes variables meant to capture the time trend: one macroeconomic indicator (the annual unemployment rate in the district, taken from Istat), and a set of year dummy variables (the base is represented by the years in the middle of the sample, 2003 and 2004). The idea is that at the beginning of the sample there was less concern for the environment than in the following years, as a result (for instance) of massive campaigns in the media. We expect this increase in concern to make the recycling waste ratio rise anyway, even if no change is made in the pricing or collection mechanism.

Identification of the year dummy variables together with the variables on the "learning effect" of PAYT and DtD is possible in our dataset because in any given year we observe municipalities without PAYT/DtD, municipalities that just started PAYT/DtD, and municipalities that started PAYT/DtD some years earlier.

Estimation is performed by means of a fixed-effects panel regression model. We prefer this type of model for several reasons. First, because it allows to get consistent estimates even if the specification omits important time-invariant variables on the structural characteristics of the municipalities. In general the coefficients μ_i capture all the (fixed) heterogeneity among the municipalities that is not explained with the other variables in the specification, such as municipality surface or intrinsic efficiency of the public administration. Second, we prefer this model for its statistical properties, since it turns out to describe the data generally better than pooled regression models (without municipality effects) and random-effects panel models (where municipality effects are not absorbed in the error term); results of these statistical tests are reported in the bottom part of Tables 2, 3 and 4.

4.3.2 Effect on The recycling waste ratio

Our results are shown in Table 2. Among the explanatory variables of equation (3) and discussed in Section 3.1, the regression in column (1) includes only the dummy variable on PAYT, and the demographic and time variables; the regression in column (2) also considers the dummy variable on DtD; finally, the benchmark regression in column (3) includes all the policy, control, demographic and time variables described in Section 3.1.

Following the literature, the specification in column (1) measures the effect of the PAYT policy alone, without trying to disentangle it from the effect of DtD collection. We find a significantly positive and large effect of the policy, informing that the introduction of PAYT raises the ratio of differentiated to total waste by a large amount (28.9%.) This number is in line with existing estimates from different datasets (see the results reported in Kinnaman, 2006).

The specification in column (2) makes a split between the effects of PAYT and DtD. Although significantly positive, the effect of PAYT (24.3%) is now slightly lower than in column (1). The reason is that we find a significantly positive effect of DtD (16.3%). This finding is also consistent

with previous works on the comparison between drop-off and DtD collection methods (see, e.g., the literature review in Kinnaman, 2006).

The benchmark specification in column (3) includes all the explanatory variables in equation (3). We still find a significantly positive effect of PAYT, although much lower than before (12.2%). This reduction depends on two reasons. First, there is a significantly positive "learning effect" of incentives, as captured by the linear trend variable associated to PAYT (1.8%). It then seems that users need time to understand and fully exploit the economic incentive represented by PAYT. Second, there is a significantly positive "emulation effect" of the confining municipalities implementing PAYT (the coefficient is estimated at 3.7%). In contrast, we find neither "learning" or "emulation" effects of DtD. This regression then suggests that the recycling ratio increases by 14.5% whenever PAYT is active, by 1.9% in every further year after PAYT implementation, and by 2.9% every time another confining municipality adopts PAYT.

Interestingly, there is weak evidence (at 10%) of a "hiding" effect of PAYT municipalities in confining towns with drop-off collection. The coefficient we estimate, 0.033, informs that the recycling ratio increases by 3.3% in municipalities with PAYT for any confining municipality with drop-off collection. We believe this may happen because users choose to throw their residual waste in public bins of near towns. However, the evidence is not statistically strong and the estimated aggregate effect of 3.3% is small compared to the effect of the policy itself, 2.2%. In all the regressions of Table 2 we also find significant effects of the number of inhabitants and the percentage of children residents. Finally, there is also a significant time effect, as shown by the year dummy variables. As expected, the values of the coefficients suggest that the recycling ratio was lower at the beginning of our sample, everything else being equal.

Table 2. Effects on the recycling waste ratio

Method: panel OLS with fixed effects Dependent variable: log(recycling ratio)	(1)	(2)	(3)
PAYT	0.289***	0.243***	0.122***
	(0.024)	(0.025)	(0.034)
Additional years of PAYT			0.018**
			(0.009)
DtD		0.163***	0.181***
		(0.026)	(0.028)
Additional years of DtD			0.014
			(0.010)
N. confining towns with PAYT			0.037***
			(0.008)
N. confining towns with DtD			-0.007
			(0.008)
PAYT × N. confining towns without DtD			0.033*
			(0.018)
log(N. inhabitants)	0.974***	1.194***	0.969***
	(0.272)	(0.268)	(0.279)
% children aged 14 or younger	0.051***	0.042***	0.041**
	(0.016)	(0.016)	(0.016)
% adults aged 65 or older	0.005	0.015	0.001
	(0.015)	(0.014)	(0.015)
% non-native residents	-0.013*	-0.010	-0.013*
	(0.007)	(0.007)	(0.007)
% unemployment rate in the district	-0.004	-0.019	-0.053
	(0.044)	(0.043)	(0.044)
Year 1999	-0.444***	-0.313***	-0.333***
	(0.056)	(0.058)	(0.061)
Year 2000	-0.326***	-0.227***	-0.238***
	(0.057)	(0.058)	(0.059)
Year 2001	-0.188***	-0.143**	-0.186***
	(0.058)	(0.058)	(0.059)
Year 2002	-0.250***	-0.180***	-0.193***
	(0.065)	(0.064)	(0.065)
Year 2005	0.006	-0.010	-0.026
	(0.030)	(0.029)	(0.030)
Year 2006	0.016	-0.014	-0.067
	(0.035)	(0.034)	(0.041)
Year 2007	0.016	-0.014	-0.071*
	(0.035)	(0.035)	(0.043)
Year 2008	0.018	-0.025	-0.115*
	(0.048)	(0.047)	(0.060)
Constant	-9.826***	-11.870***	-9.551***
	(2.471)	(2.438)	(2.538)
Observations	950	950	950
Number of municipalities	95	95	95
Fraction of variance due to ind. effects	0.940	0.959	0.946
Test for municipality effects	4.640	4.290	4.740
(pooled OLS Vs. fixed-effects panel)	[0.000]	[0.000]	[0.000]
Test for random effects	51.530	55.030	96.630
(random-effects Vs. fixed-effects panel)	[0.000]	[0.000]	[0.000]

*Note: Standard errors in round brackets; p-values in square brackets; *** p<0.01, ** p<0.05, * p<0.1.*

4.3.3 Components of the recycling waste ratio

We conclude our analysis by looking more closely at the two aggregate components of the recycling waste ratio: sorted waste and total (sorted plus residual) waste. Table 3 shows the estimates of the model in equation (3), where the dependent variable is now the logarithm of per capita sorted waste in kilograms (column 1) and the logarithm of per capita total waste in kilograms (column 2).

The reason why we look at the determinants of these variables is that the recycling ratio may increase as a result of an increase in sorted waste, a reduction in residual waste, or both. From the results in Table 2 we cannot say anything regarding this issue. However, knowing this is important as it provides more precise information on how the PAYT incentive works. We expect that, by increasing the relative cost of producing residual waste, PAYT makes it more convenient to increase sorted waste. In contrast, it should have no implications on the production of total waste. However, this will happen provided that the economic incentive works properly.

The regression output supports our hypothesis. Indeed, we find for PAYT a significantly positive effect on per capita sorted waste (which rises by 9.6%; see column 1), and an insignificant effect on per capita total waste (the coefficient -0.026 is statistically equal to zero; see column 2).

In addition, we find that the "emulation" effect of near municipalities with PAYT is significant only for sorted waste (4.3% for each near municipality, see column 1). However, column (2) also shows weak evidence (at 10%) that the production of total waste falls by a small amount (1.7%) when PAYT programs are active and there are confining municipalities with drop-off collection. It should be stressed, though, that this effect is small, as it was the hiding effect we found in column (3) of Table 2. In contrast, we find that DtD increases per capita sorted waste (which rises by 7.6%; see column 1) and it also reduces per capita total waste (by 10.5%; see column 2). This effect suggests that DtD may be seen as a form of non-monetary incentive aimed to increase sorted waste – it eliminates the time costs of carrying waste to the streets – and reduce total waste – it imposes constraints to the amount of waste production (a given size of personal bins and a given frequency of waste collection). Reducing the amount of total waste is certainly important from a policy perspective.

Table 3. Effects on the amount of per capita waste production (kgs.)

Method: panel OLS with fixed effects Dependent variable: log of per capita waste	(1) Sorted waste	(2) Total waste
PAYT	0.096***	–0.026
	(0.034)	(0.018)
Additional years of PAYT	0.012	–0.006
	(0.009)	(0.005)
DtD	0.076***	–0.105***
	(0.028)	(0.015)
Additional years of DtD	–0.012	–0.026***
	(0.010)	(0.005)
N. confining towns with PAYT	0.043***	0.006
	(0.008)	(0.004)
N. confining towns with DtD	–0.010	–0.003
	(0.008)	(0.004)
PAYT × N. confining towns without DtD	0.016	–0.017*
	(0.018)	(0.010)
log(N. inhabitants)	0.149	–0.820***
	(0.275)	(0.146)
% children aged 14 or younger	0.036**	–0.005
	(0.016)	(0.008)
% adults aged 65 or older	–0.003	–0.004
	(0.014)	(0.008)
% non-native residents	–0.013*	–0.000
	(0.007)	(0.004)
% unemployment rate in the district	–0.008	0.046**
	(0.044)	(0.023)
Year 1999	–0.515***	–0.182***
	(0.060)	(0.032)
Year 2000	–0.366***	–0.127***
	(0.058)	(0.031)
Year 2001	–0.263***	–0.077**
	(0.058)	(0.031)
Year 2002	–0.222***	–0.029
	(0.064)	(0.034)
Year 2005	0.010	0.036**
	(0.029)	(0.016)
Year 2006	0.062	0.129***
	(0.040)	(0.021)
Year 2007	0.083**	0.154***
	(0.042)	(0.022)
Year 2008	0.124**	0.238***
	(0.059)	(0.032)
Constant	3.556	13.110***
	(2.506)	(1.332)
Observations	950	950
Number of municipalities	95	95
Fraction of variance due to ind. effects	0.633	0.983
Test for municipality effects	10.410	24.790
(pooled OLS Vs. fixed-effects panel)	[0.000]	[0.000]
Test for random effects	70.870	107.670
(random-effects Vs. fixed-effects panel)	[0.000]	[0.000]

*Note: Standard errors in round brackets; p-values in square brackets; *** p<0.01, ** p<0.05, * p<0.1*

4.4 Discussion

In this paper we use a unique dataset on waste management in an Italian district to investigate the effect on the recycling ratio of the economic incentive represented by Pay-As-You-Throw (PAYT) pricing, in combination with the non-economic incentive represented by Door-to-Door (DtD) waste collection. We find evidence that the PAYT incentive has the net effect of increasing the recycling waste ratio by around 12.2%, that is complementary to the net effect of the DtD incentive (18.1%). In addition, municipalities with a PAYT program increase the amount of per capita sorted waste by 9.6%, but have no bearings on the amount of per capita total waste. Our results are obtained controlling for specific characteristics of the municipalities, and they are robust to different assumptions of the model. Our findings thus confirm that, in aggregate, well designed economic incentives are an effective way to promote virtuous behavior, and they suggest decision makers "not to trash economic incentives".

The analysis in the paper is performed at the municipal level. Future research should take a closer look at individual data, where there may be negative consequences of adopting PAYT for particular users. We will focus on three main issues. First, we will dig on cases of illegal dumping and garbage tourism where users may want to "hide" their waste to pay less (see for instance Fullerton and Kinnaman, 1996). In our analysis we control for this effect in aggregate by considering that users living in municipalities with PAYT may want to carry their waste in confining towns with drop-off collection over the streets. We find some weak evidence in support of this view. However, the effect of this deviating behavior seems small. The use of individual data will tell us if it is the effect to be small, or rather the deviating behavior is not widespread. Second, we will consider the perceived unfairness of PAYT pricing. PAYT is sometimes considered unfair (Batllevell and Hanf, 2008) since citizens do not pay proportionally to their income or wealth. This pricing may create stronger incentives for the poorest ones than for the richest ones. Data at the individual level will shed light on this issue. Finally, we will look at free-riding problems. These may arise when the payment depends on the behavior of many users, as in multi-property buildings. Understanding who is more likely to be influenced by monetary incentives will help the policy maker to implement a menu of incentives targeted to different segments of users, improving the efficiency and the effectiveness of waste management policies.

References

1. Allers, M.A., and C. Hoeben (2010), "Effects of Unit Based Garbage Pricing: A difference and Difference Approach", *Enviromental Resources Economics*, 45, 405-428.

2. Angrist, J., Lavy, V., (2009), The effects of high stakes high school achievement rewards: Evidence from a randomized trial., *American Economic Review*, 99(4), 1384-414.

3. Ariely D., U. Gneezy, G. Loewenstein and N. Mazar (2009), Large Stakes and Big Mistakes, *Review of Economic Studies*, 75, 1–19.

4. Arpav (2000), *La raccolta differenziata nella Regione Veneto*, ISBN: 88-7504-016-8.

5. Arpav (2009), Produzione e gestione dei rifiuti nel veneto - anni 2007-2008, ISBN: 88-7504-144-X, available online at: http://www.arpa.veneto.it/pubblicazioni/htm/scheda_pub.asp?id=215.

6. Batllevell, M., and K. Hnaf (2008), "The Fairness of PAYT Systems: Some Guidelines for Decision Makers", *Waste Management*, 28, 2793-2800.

7. Benabou, R., and J. Tirole (2003), "Intrinsic and Extrinsic Motivation", *Review of Economic Studies*, 70, 489-520.

8. British Society for Ecological Medicine, "The Health Effects of Waste Incinerators", available online at:

   http://www.ecomed.org.uk/content/IncineratorReport_v2.pdf

9. Belkin, D., (2002), Boston firefighters sick-or tired of working. Boston Globe 18 january, Third ed.: B1: Boston.

10. Bowles, S., (2008), Policies Designed for Self-Interested Citizens May Undermine "The Moral Sentiments": Evidence from Economic Experiments, Science, 320, 1065(2008).

11. Bowles, S., and Hwang S., (2010), Are incentives overused in case where they crowd out pro-social motivations?, wp, 2010.

12. Charness, G., and U. Gneezy (2009), "Incentives to Exercise." *Econometrica*, 77 (3), 909-931.

13. Cook, P.J., and and G. Tauchen (1982) "The Effect of Liquor Taxes on Heavy Drinking", *The Bell Journal of Economics*, 2, 379-390.

14.   Dionne, G., J. Pinquet, M. Maurice, and C. Vanasse (2010), "Incentive Mechanisms for Safe Driving: A Comparative Analysis with Dynamic Data", *Review of Economics and Statistics*, doi:10.1162/REST_a_00054.

15.   Eurostat (2010), Eurostat News Release: Enviroment in EU27, 43/2010, 19 march 2010.

16.   Frey, B.S., F. Oberholzer-Gee (1997), "The Cost of Price Incentives: An Empirical Analysis of Motivation Crowding-Out", *American Economic Review*, 87(4), 746-55.

17.   Fullerton, D., and T.C. Kinnaman (1996), "Household Responses to Pricing Garbage by the Bag." *American Economic Review*, 86, 971-84.

18.   Galbiati, R., and Vetrova, P., (2008), Obligations and cooperative behavior in public good games., *Games and Economic Behavior*, 64(1), 146-170.

19.   Gneezy, U., and A. Rustichini (2000), "A Fine is a Price", *Journal of Legal Studies*, 29(1).

20.   Gruber, J., and B. Köszegi (2001), "Is Addiction 'Rational'? Theory and Evidence", *Quarterly Journal of Economics*, 116(4), 1261-1303.

21.   Harrison, G.W., and J.A. List (2004), "Field Experiments", *Journal of Economic Literature*, 42, 1009–1055.

22.   Health Protection Agency, 2005, "HPA response to the British Society for Ecological Medicine report", available online at: http://www.ecomed.org.uk/content/IncineratorHPA.pdf

23.   Jacobson, M., and K. Brownell (2000), "Small taxes on soft drinks and snack foods to promote health", *American Journal of Public Health*, 90, 854–857.

24.   Kinnaman, T.C. (2006), "Policy Watch Examining the Justification for Residential Recycling", *Journal of Economic Perspectives*, 20, 219-232.

25.   Kinnaman, T.C. and D. Fullerton (2000), "Garbage and Recycling in Communities with Curbside Recycling and Unit-Based Pricing." *Journal of Urban Economics*, 48, 419-42.

26.   Legambiente (2009), Comuni Ricicloni 2008, available online at:

27.   http://risorse.legambiente.it/docs/DossierCR2008.0000001126.pdf

28.   Miranda, M.L., Everett, J., Blume, D., and Roy, B., (1994) Market-Based Incentives and Residential Municipal Solid Waste, *Journal of Policy Analysis and Management*, 13(4), 681-697.

29.   Rosenthal, E., (2008), Motivated by a Tax, Irish Spurn Plastic Bags, New York Times.

30.   Reschovsky, J.,D., and Stone S., E., (1994), "Market Incentives to Encourage Household Waste Recycling: Paying for What You Throw Away", *Journal of Policy Analysis and Management*, 13(1), 120-139

Appendix A. Municipalities and consortia in the datasets

Italy has four administrative levels (national, regional, provincial/district and municipal) and each one takes some responsibility for waste management. The national level defines the legislative framework and sets targets coherent with the European Directives. Since 1994 each region delegates the management of waste to an office called "Ambito Territoriale Ottimale" (ATO). The office sets targets on landfilling biodegradable municipal waste and separate collection of municipal waste. Districts are responsible for meeting the targets defined by their ATO. In order to reach the targets, they are free to implement their preferred waste management policies.

As Figure A.1 shows, the district of Treviso (the darker colored area) is located in North-Eastern Italy, in the region called Veneto (the lighter colored area). The district covers an area of 2,477 square kilometers and has 879,408 inhabitants, with a density of 335 inhabitants per square kilometer. The district is divided in 95 municipalities, almost all of relative small size: only one municipality, Treviso, has more than 50,000 inhabitants; 24 municipalities have between 10,000 and 50,000 inhabitants; 36 between 5,000 and 10,000; 34 have fewer than 5,000 inhabitants. On average each municipality has 9,303 inhabitants. The area is relatively rich, as the average per capita GDP in 2008 is 30,274 Euros, as opposed to the national level of 26,278 Euros.

Figure A.1. The Veneto region (light color) and the district of Treviso (dark color) in Italy.

The regional plan for the management of urban waste in 1988 divided the Treviso district into 3 territorial units aimed to centralize decisions regarding waste management policies that, up to that moment, were taken by the municipalities independently. A consortium grew within each unit to set the targets for recycling rates and costs of the system, and to decide the management policy, in terms of waste collection and billing. After the creation of the three consortia Priula, Savno and TV3, municipalities were suggested, although not forced, to join at any time the "consortium" controlling their area (see Figure A.2).

Figure A.2. Consortia and municipalities in the district of Treviso
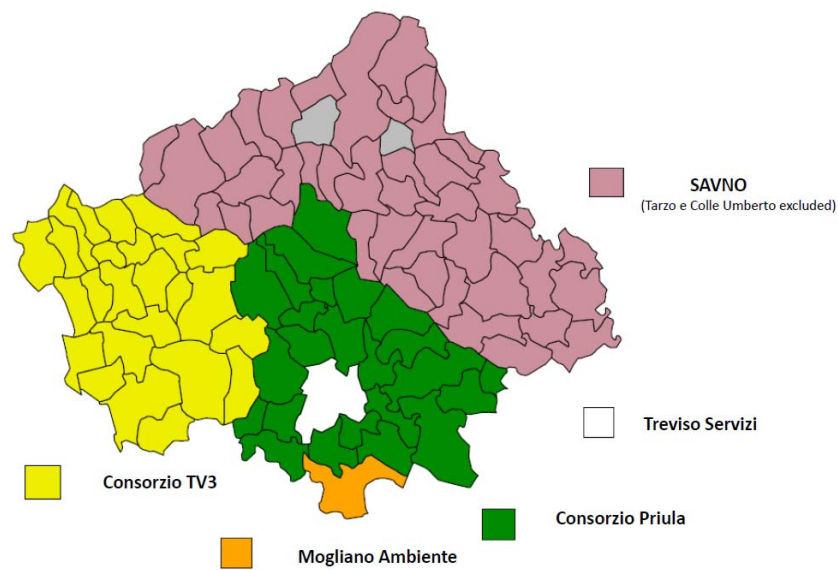
Adhesion was gradual, although most of the municipalities (80 out of 95, or 84%) were already connected to a consortium at the beginning of our sample period (1999; see Figure A.3). Currently 91 out of the 95 municipalities belong to one consortium. The exceptions are Colle Umberto, Tarzo, Mogliano Veneto and Treviso, that chose not to adhere respectively to Savno (the first two municipalities), Priula and TV3.

Importantly, in 1999 nearly all the municipalities in the district were implementing drop-off collection systems with flat fee pricing. Since 2000, they started following different policies. In particular, in 2000, Priula introduced in some municipalities a DtD program paired in the following year with a PAYT program based on the volume of residual non-recyclable waste produced. The

volume is measured by counting the number of emptying during the year[48] of specific bins for residual waste. These bins have a capacity of 120 liters, and are equipped with a transponder that can be emptied not sooner than every two weeks[49]. This transponder records the number of times the container is emptied. In 2008 the average number of emptyings per year was 7.5 for a household of 3 members and 10.5 for a household of 5 members. In 2008 the yearly cost for family in the consortium was approximately 140 Euros. Consortium TV3 also started introducing DtD in 2000 but, contrary to Priula, up to 2008[50] it kept using flat-fee pricing rather than PAYT pricing. In the second half of 2009 TV3 also started a PAYT program similar to the one in Priula. We do not use this information, and stop our dataset to the end of 2008, since data for 2009 are likely to be biased for the transition from one system to the other (our end-of-year data would inform on what happened in both the first semester with flat fee pricing, and the second semester with PAYT). In 2008 the yearly cost per family in the consortium was approximately 96 Euros.[51]

Figure A.3. Trends in consortium adhesion

% of municipalities joining a consortium

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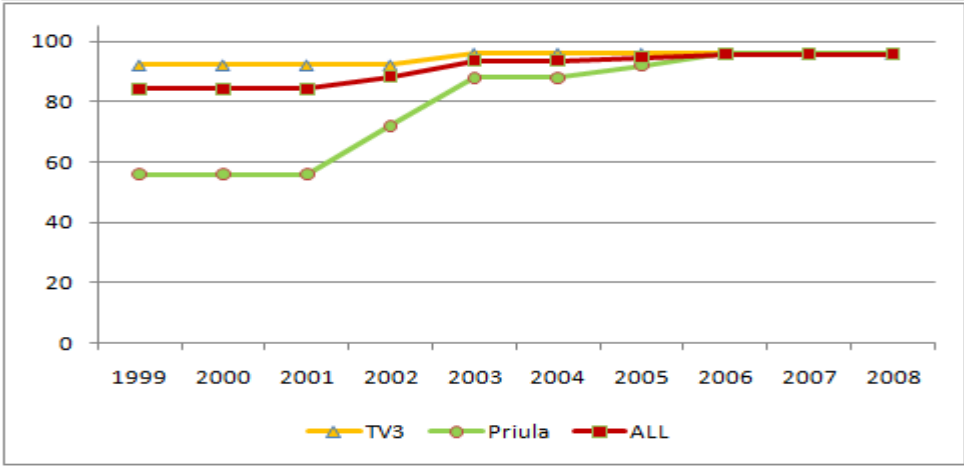
[48] For flat buildings the variable part of PAYT depends on the volume of the common container and on the number of times that the container is emptied divided for the number of flat. On average, in 2008 the fixed cost θ_0 was equal to € 82.38 euros, and the variable cost θ_1 was equal to 10.39 euros per emptying. Costs vary over the years. In particular, fixed costs depend on a number of factors, not all strictly related to the collection of waste (such as municipality taxes). Variable costs are instead independently decided from the consortium, and every year their grow with inflation.

[49] Given this limit on the maximal frequency in one year a maximum of 26 emptyings are possible.

[50] In the second half of 2009 also TV3 started a PAYT program similar to the one in Priula. We do not use these data as they are likely to show the transition from one system to the other (our end-of-year data would inform on what happened in both the first semester with flat fee pricing, and the second semester with PAYT).

[51] Pricing follows the flat fee formula in (1). Coefficients differ for each municipality, as they depend on a number of factors such as population size and tourist arrivals. They also depend on the nature of the service (e.g. museums have to pay less than restaurants and private houses have to pay less than shops, etc).

The third consortium, Savno, adopt a DtD collection system but it is more heterogeneous in the pricing system: some municipalities adopt a flat fee which only depends on house' surface and/or on the number of family components; others adopt a volume based pricing system similar to the one adopted in Priula.

We now report some facts on the three consortia. Statistics are drawn from our dataset and refer to year 2008.

Consortium Priula (http://www.consorziopriula.it), created in 1987, includes 24 municipalities covering an area of 640 square kilometers with around 240,000 inhabitants. The municipalities in the consortium reached the 77.06% of differentiated-to-total waste in 2008, gaining the first place in the national rankings (source: Legambiente, 2009).

Consortium TV3 (http://www.tvtre.it/), created in 1993, includes 25 municipalities and operates on a territory of 620 square kilometers with around 220,000 inhabitants. The municipalities in the consortium reached the 66.56% of differentiated-to-total waste in 2008.

Consortium Savno (http://www.savnoservizi.it), created in 1995, operates in 42 municipalities, for an area of 1,080 square kilometers with around 298,000 inhabitants. These municipalities show different methodologies in DtD collection (allowing for partial drop-off) and different types of incentive system. Savno has differentiated the 72.53% of produced waste in 2008, gaining the third place in the national rankings (source: Legambiente, 2009).

Appendix B. Door-to-Door collection and billing systems

We briefly illustrate the different waste collection methods adopted in the municipalities of the Treviso district.

Drop-off collection system

Sorting of municipal waste through drop off is organized by placing along the streets different large containers for different types of waste (drop-off points) where users voluntarily leave their waste. The main problem of this collection system is the damage for the urban image and quality of life (see figure B.1).

Figure B.1. A drop off point for sorted and residual waste

Door-to-door collection system

The door to door (DtD) collection system assigns to each user different small containers for different types of waste (see Figure B.2). Waste is sorted and kept in each house until the day in which it is going to be collected, where containers are placed in the streets, just outside each house.

Figure B.2. Containers for organic waste and residual waste in Priula

Waste is collected periodically according to a calendar known to the users (see for instance Figure B.3).

Figure B.3. Consortium Priula' DtD collection calendar

The consortia share similar schedules for waste collection and similar containers for waste storage. Moreover, the type of material admitted in each sorted fraction (plastic, paper, glass, etc) is identical across consortia as defined in the European Commission Decision 2000/532/CE (see for instance Figure B.4). There are two unique exceptions: first, glass and plastic are collected together in Priula and in some municipalities in Savno, and separately in the rest of the municipalities. Second, tetra pack is not sorted in Priula, differently than in TV3 and Savno. This is essentially due to the recycling technology of the recipient center where sorted waste is delivered after the collection.

Figure B.4. Fractions of sorted waste

	TV3	PRIULA
Residual waste		
Food waste		
Garden waste		
Paper and cardboard		
Glass Plastic Cans		

Drop-off collection system and PAYT pricing

The implementation of a PAYT pricing system requires the ability to identify who produces what. In Priula and in some municipalities of Savno identification is realized through an electromagnetic transponder which is installed in every residual waste bin (see Figure B.5).

Figure B.5. The transponder for the identification of the residual waste production

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Every time the container is placed out of the house for the collection, a reader device turns the signal into an alphanumeric code which univocally identifies the container and the owner. This way data on the unsorted waste production for each user are recorder and processed.