Reciprocity in Teams: a Behavioral Explanation for Unpaid Overtime*

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Abstract

Relying on the relevance of other regarding preferences in workplace, we provide a behavioral explanation to the puzzle of unpaid overtime. In an agency theory frame we characterize the optimal contracts which both under symmetric and asymmetric information about agents' action, induces overtime by exploiting their horizontal reciprocity. Finally, we show that reciprocity may represent a rationale for the composition of team of reciprocal agents when the production technology induces negative externality among the workers' efforts.

Key Words: Overtime, Horizontal Reciprocity, Negative Reciprocity.
JEL Classification: D03; D83; J33.

1 Introduction

There is evidence of *unpaid overtime* in modern industrialized societies.[1] Eurostat reports that in 2001 the average European wage earner was paid only about 5 hours over 9 hours worked overtime per week (Eurostat, 2004). In Canada the percentage of employees working overtime has increased from 18.6% in 1997 to 22.6% in 2007 with the 11.4% working overtime unpaid (Statistics Canada, 2008). Overtime is an advantage for the firm as it allows flexible adjustment in the presence of market fluctuations. From the employee perspective, even if it may entail negative consequences in terms of health, safety and family life, paid overtime is

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[1] The report ILO (2002) defines overtime as "all hours worked in excess of the normal hours". The definition of normal hours is fixed 48 hours per week by ILO Hours Work (Industry) Convention (No.1, 1919). The report points out that overtime "does not necessarily need to be linked to compensation".

still seen as the way to top–up the base salary[2] (ILO, 2004). Overtime is a country-specific phenomenon in that it may differ changing the national institutional frame. However, some common features can be identified.[3] For instance, men are more likely to work overtime and to be paid for it than women. In most Member States, overtime is mainly provided by employees aged 55 and over, with only less than 50% paid. Overtime by machine operators and assemblers is in the most part paid. On the contrary overtime by senior officials, managers and professionals is often unpaid, (Eurostat, 2004; Eiro, 2008).

Why should employees work overtime without compensation? Two main research hypotheses have been investigated. The first explains overtime as an *investment in human capital.* By providing overtime workers aim to minimize the risk of getting fired and/or maximize the probability of better conditions (promotion, higher wage, etc.), (Eiro, 2008; Van Echtelt et al., 2007). The second one considers overtime as the action, not necessarily productive, by which workers *signal* their intrinsic motivation or ability. Empirical investigations are not totally convincing about the strength of such explanations. An analysis on the German socio economic panel data (GSOEP) provided by Pannenberg (2005) reveals a long term labor real earnings effect associated with unpaid overtime for *male workers* in West Germany. Per contra, even if considerable amount of female unpaid overtime is documented, the *investment* component is not statistically significant. Using the same data, Anger (2008) provides instead support for the *signaling* value of unpaid overtime. This result holds for West German workers but not for workers in the East Germany. Booth et al (2003), analyzing the British labor market, compare unpaid and paid overtime and report no difference in the impact on the probability of a subsequent promotion. Similarly, in a study on temporary workers in Sweden, unpaid overtime has no effect on favoring the passage from temporary to permanent job (Meyer and Wallette, 2005). Moreover, how to explain evidence of unpaid overtime in the public sector, where a promotion is not decided by the boss, (Eurostat, 2004)? Or, why should workers at the end of their career or at the top of their organization hierarchy work unpaid overtime, (Pannenberg, 2005)?

These conflicting results show that unpaid overtime may not be exhaustively explained in terms of investment or signal device. This may be due to have modeled the worker ignoring the relevance in his behavior of *Other Regarding Preferences*[4] (hereafter, ORP). Individuals are not solely motivated by self interest but they care - *positively* or *negatively* - about material payoff of relevant referent others.[5] It follows that the incentive system in a organization need to be designed carefully as effort choices could be affected not only by the

[2]Bell and Hart (1999) evidence that adjusting wages for unpaid overtime hours implies a reduction in the estimated returns to education, experience and tenure.

[3]Galarneau (1997) and Böckerman (2002) studies respectively Canada and Finland. Bell et al. (2001) compare unpaid overtime in U.K and Germany. Mizunoya (2002) analyzes U.S., Canada, Japan, Germany and U.K. Freyssinet and Micron (2003) studies Hungary, Poland and Slovakia. Fear and Denniss (2009) focus on Australia.

[4]See Camerer and Weber, (2010) for a survey on incentives and ORP in organizations. Fehr and Fischbacher, (2002) and Rotemberg, (2006) review respectively experimental and theoretical results on ORP in the workplace. Kube et al., (2006) report evidence form field experiments.

[5]In addition to ORP, has been showed that workplace interactions may also be affected by other factors as *emotions* (Bosman et al., 2007), *social ties* (Bandiera et al., 2009), *social norms* (Huck et al., 2001).

monetary compensation but also by the way ORP respond to payoffs (Bowles and Polania Reyes, 2009).[6]

Including in the frame ORP we aim to explain unpaid overtime allowing for *horizontal reciprocity.* Reciprocity describes the willingness to respond fairly to kind action and unfairly to nasty actions, (Rabin, 1993). We deliver from *vertical* reciprocity[7] focusing on *reciprocity* among peers to capture what, according to the Social Comparison Theory, is a natural tendency: people make comparisons, especially with others having their same status[8] (Festinger, 1954). Furthermore, *mutual-help* among employees (Corneo and Rob, 2003), *social sanctioning* of free riders (Carpenter and Matthews, 2009) and *social support* among co-workers (Mossholder et al., 2009) could be interpreted as manifestations of reciprocity. It seems evident that repetitive interactions and team work create an environment where each worker could affect the team activity and the compensation of other team members. In such a context, horizontal reciprocity matters as each worker *compares* what he (and other team mates) earns to what he would have obtained as a consequence of an *alternative* choice by his colleagues[9].

We define reciprocity as in Cox et al. (2007)'s model, where the fairness of one player's action is evaluated by looking at the *material consequence*s it has on the utility function of the other player.[10] In a principal-multi agents frame, we show that the principal may exploit reciprocity to elicit productive overtime without full compensation. This happens when, offering a *relative compensation* scheme, *negative* reciprocity is induced. We characterize the conditions under which agents motivated by reciprocity work unpaid overtime. In our frame, each agent exerts under- or unpaid overtime to prevent his colleague gaining from being the sole one working overtime. This result seems to be consistent with empirical evidence by Van Echtelt et al. (2007), where, analyzing Dutch firms, *work pressure* (defined as workers negative motivation) has a strong predictive effect for spending additional unpaid hours at work. Similar results are obtained in a different frame by Rey Biel (2008) and Dur and Sol (2009). In Rey Biel (2008) a principal exploits, still offering a relative performance contracts, the *inequity aversion* of her agents to induce effort without fully compensating its cost. However, in his paper agents derive disutility form differences between themselves and others while in our model agents are not interested in the relative final pay-off rank per sè, but they use it as a reference in evaluating the fairness of their mates. In Dur and Sol's model workers can devote part of the effort in *social interaction* with their colleagues. In equilibrium positive reciprocity arises in that a worker treated kindly will care more about the wellbeing of the colleagues. This implies an increased job satisfaction balancing lower wages. As in our model monetary incentives and ORP are substitutes but we differ in the

[6] Intrinsic motivation *crowding out* (Gneezy and Rustichini, 2000) and an *over-justification* effect (Bénabou and Tirole, 2006) are examples of unexpected negative effect.

[7] *Vertical* reciprocity has been extensively analyzed starting with the seminal paper by Akerlof, (1982). For a survey of experimental results see Fehr and Gächter, (2002).

[8] Differently from us, studies on ORP among peers have focused on *peer pressure* (Falk and Ichino, 2006), *conformism* (Gächter and Toni, 2009), *inequity aversion* (Rey Biel, 2008) and *altruism* (Rotemberg (1994).

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

[10] Appendix A1 discusses the Cox et al (2007) formulation and derives ours. For a discussion on the role of *belief*s and *expectation*s as well as *real* behavior in conceptualizing reciprocity, see Perugini et. al, 2003.

base for reciprocity. For us reciprocity relates to what happens on the workplace (and for this reason it is deeply affected by the incentive system) while to be kind in the model of Dur and Sol means to show "interest in the colleague personal life, offering a drink after working hours...", (pag. 2).

Finally, we show that horizontal reciprocity may represent a rationale for the composition of team of reciprocal agents when the production technology induces negative externality among the workers' efforts. By inducing a form of *endogenous complementarity* among agents' actions, Potter and Suetens, (2009), reciprocity mitigates the negative externality imposed by the production technology. This result complements the work by Gould and Winter, (2009), that focuses on the effort choices of self interest agents under different production technologies.

The paper is organized as follows. Section 2 illustrates the model and discusses the definition of horizontal reciprocity. Section 3 characterizes the optimal contract under both symmetric and asymmetric information. Section 4 presents some extension. Section 5 concludes. All the proofs are available in the Appendix.

2 The Model

We model overtime provision in a standard agency frame. We consider a risk neutral principal (P) that employs a team of two risk neutral agents: A_i, with $i \in \{1,2\}$, and $i \neq j$, where the index refers to the timing of the agent's action[11]. The principal and the agents contract some extra activities with respect to those included in the job contract, typically *overtime* or *extra-effort*. For this reason we assume the participation constraints to be satisfied. The principal demands each agent to undertake *overtime.* Each agent has the following action set: $a_i \in \{0, e\}$ with $i = 1, 2$,where $a_i = 0$ and $a_i = e > 0$, indicates whether the agents refuse to undertake overtime, or not. The cost of undertaking overtime is $c_i(e) > c_i(0) = 0$.We assume that agents are identical with respect to productivity and disutility of effort and can observe their colleague's choice. Finally let $X(\gamma, a_i, a_j) = \gamma(a_i + a_j)$ be the production function.[12] The timing of the game is the following: at $t = 0$ the principal offers a complete compensation scheme for the overtime provision: $w_i(a_i, a_j)$, for $i, j \in \{1,2\}$ and $i \neq j$. At $t = 1$, A_1 has observed the compensation scheme and decides whether to undertake overtime or not. Then, at $t = 2$ Agent 2, has observed both the compensation scheme and the action chosen by the team mate and he chooses a_2. Once $X(\gamma, a_i, a_j)$ is realized, at $t = 3$, compensations are paid. We solve the game by backward induction, applying Subgame Perfect Nash Equilibrium as solution concept.

The principal maximizes the following profit function:

$$\Pi = X(\gamma, a_i, a_j) - (w_i + w_j) \tag{1}$$

If $\gamma > \frac{w}{e}$, the principal obtains her highest profit when both agents undertake overtime.

[11] From now on, we will assume the principal is female and agents are males.

[12] Since our results are not affected by the functional form, we assume a linear production function to keep the frame as simple as possible.

Let M_i denote the agents's *material* payoff. That is the compensation received minus the cost of undertaking overtime:

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

Agents maximize the following utility function:

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

where the exogenous term $\rho_i \in [0, 1)$ measures the impact of reciprocity concern in agent i's utility function. We define as *standard* agents those who have $\rho_i = 0$ and then they care only about their own material payoff. *Reciprocal* agents are those agents for which $\rho_i > 0$ and they also care on the other agent's material payoff in a way that is defined by the endogenous *reciprocity term* r_{i,σ_j}. Denote by H_i and L_i respectively the highest and the lowest monetary payoff for A_i. Let σ_j and σ_j' be two strategies of A_j, with $\sigma_j \neq \sigma_j'$. The reciprocity term of A_i, given that A_j chooses the strategy σ_j, is defined as follow:

$$r_{i,\sigma_j} = \frac{\underset{\{\sigma_i\}}{max}\{M_{i,\sigma_j}\} - \underset{\{\sigma_i\}}{max}\{M_{i,\sigma_j'}\}}{H_i - L_i} \in [-1, +1] \tag{4}$$

The reciprocity term in (4) is determined by the difference between the maximum material payoff which A_i can obtain - given the strategy σ_j chosen by A_j- and the maximum material payoff A_i could have reached under the alternative strategy choice $\sigma_j\prime$. This difference is then normalized by $H_i - L_i$. When $r_{i,\sigma_j} > 0$, A_i evaluates positively (negatively) A_j's material payoff. This implies that if $M_j > 0$ (< 0), the material payoff of A_j enters as a positive (negative) *externality* in the utility function of A_i. The reciprocity term accounts for the *intentionality* of A_j's choices. A_i evaluates A_j 's kindness by comparing how the A_j's chosen and not chosen strategies affect his own material payoff.[13]

In this paper we design the optimal compensation scheme a principal should offer to induce workers to undertake overtime. Consistently we assume that workers are already within the firm and the participation constraints are satisfied. Nevertheless, to avoid trivial solutions, we assume that the principal 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 $w_1 + w_2 \leq B$.

3 The Optimal Compensation Scheme

3.1 The Optimal Compensation Scheme under Symmetric Information

We assume that the principal can observe ρ_i and overtime choices. In this frame, we determine an optimal compensation scheme for reciprocal agents where compensations are

[13] 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 matter, Falk et al. (2003).

conditional to each agent action. Let us denote by $w_i^S(a_i, a_j)$ for $i, j = 1, 2$,with $j \neq i$ the optimal compensation scheme for standard agents ($\rho_i = 0$). This scheme will be used as benchmark. The optimal compensation scheme $w_i^S(a_i, a_j)$ is such that, irrespectively from the action chosen by the team mate, each agent receives a compensation $w_i^S(e_i, a_j) = c$ if he provides overtime and $w_i^S(0, a_j) = 0$ otherwise,[14] for both $i, j = 1, 2$,with $j \neq i$. The principal pays a sum of compensations equal to $2c$ and $\Pi^S = 2(\gamma e - c)$ as profit.

In the utility maximization problem for agents with reciprocity concerns ($\rho_i > 0$), not only the material payoff matters but also the other agent's strategy.

Proposition 1 *Under symmetric information and $\rho_i > 0$ for $i = 1, 2$ with $j \neq i$, the optimal compensation scheme is a tournament that induces negative reciprocity. Each agent receives a monetary compensation equal to B if and only if he is the only one undertaking overtime, and no compensation otherwise. In equilibrium, if $B \geq c(\frac{1}{\min\{\rho_i, \rho_j\}} + 1)$ then the principal obtains the output level $X(\gamma, e_1, e_2)$ without paying any compensation.*

Proof. See Appendix A2. ■

See Figure 1. Consider A_2. If A_1 *does not exert* effort, A_2 has an incentive to undertake overtime, since he earns the highest material compensation, $w_2(0, e_2) = B$. If A_1 *does exert* effort, A_2, motivated by negative reciprocity, prefers to provide unpaid overtime rather than not, precluding to A_1 the possibility to earn the highest payoff: $w_1(e_1, 0)$. A_2's behavior is due to the role played by negative reciprocity.

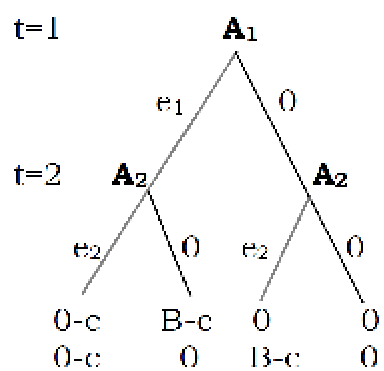

Figure 1

Since A_1's overtime choice enters in A_2's utility function as a negative externality and this externality is increasing with $w_1(e_1, 0)$, then the principal will find convenient to fix out of equilibrium the highest possible compensation inducing A_2 to provide unpaid overtime

[14]This is only one of the several possible optimal contracts. 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 $w_1(0, 0)$ 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 $X(\gamma, e_1, e_2)$ at the cost of $2c$.

$(w_1(e_1, 0) = B)$. In fact, if the negative externality is higher then the cost of providing overtime then A_2 will work for free to prevent it. By a similar argument, A_1 anticipates A_2's behavior and chooses to provide overtime as well.

The minimum level of payment that must be offered out of equilibrium to induce unpaid overtime is $\underline{B}= c(\frac{1}{\min\{\rho_i,\rho_j\}}+1)$. Note that $\underline{B}$ is increasing with the disutility of effort, c_i, while it is decreasing with ρ_i. Intuitively, for any given compensation offered out of equilibrium the higher the impact of the agent's reciprocity concern the easier is for the principal to induce unpaid overtime. Note that when ρ is close to 1,the B that has to be offered out of equilibrium approximates to $2c$, which is the budget required to induce overtime by standard agents. In a similar way, the greater is the disutility of agents' effort, the more costly will be for the principal to exploit their reciprocity concerns[15].

In our model if the principal demands overtime to both agents, a compensation scheme inducing *positive* reciprocity is always more costly than a compensation scheme offered to standard agents.[16]

In addition, note that since we are assuming that principal could observe ρ, she always prefers to demand overtime to reciprocal types since she obtains overtime by both agents at no cost.

Corollary 1 *Agents that exhibit reciprocity concerns ($\rho > 0$) are always preferred to standard agents.*

In the Appendix we rank the principal preferences over teams composition. We show that a team composed by two reciprocal agents is always preferred to a team composed by a standard agent and a reciprocal agent. Consistently, a team composed by a standard and a reciprocal agent is always preferred to team composed only by standard agents.

3.2 The Optimal Compensation Scheme under Asymmetric Information

In this section and for the rest of the paper we assume that the principal only observes the agents type ρ and output level produced by the team.[17] Under asymmetric information a complete compensation scheme specifies the rewards offered to both agents *conditional* to the *realized output* and it is profit maximizing. In this respect three different output levels can be defined: $X(\gamma, e, e) = X^H > X(\gamma, e, 0) = X(\gamma, 0, e) = X^M > X(\gamma, 0, 0) = X^0$ where

[15] By offering this compensation scheme the principal puts her agents in a situation similar to a *sequential-prisoners dilemma*, where each agent is not able to credibly commit on 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 to the agents incentive for colluding. However, we believe that the one-shot nature of our game better capture the non regularity of overtime demand.

[16] See Appendix A.3 for a formal proof. In Appendix A.4 we also show that, when the optimal compensation scheme designed for standard agents is offered to reciprocal agents, the ORP are neutralized.

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

the indexes indicate respectively: high, medium and null output.
As under symmetric information, we take as benchmark the case with standard agents. In this case the scheme assigns to each agent a compensation equal to $w_i(X^H) = c$, if the X^H is produced, and no compensation otherwise.[18] The principal obtains $\Pi^S = 2(\gamma e - c)$ by paying a sum of compensations equal to $2c$.[19]

Proposition 2 *Under asymmetric information and $\rho_i > 0$ for both $i = 1, 2$, the optimal compensation is an asymmetric payment scheme that induces negative reciprocity. Agent 1 receives a positive monetary compensation equal to B if and only if X^M is produced and Agent 2 receives a positive monetary compensation equal to B if and only if X^0 is produced. When $B \geq \max\left\{\frac{c}{\rho_1}, c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2}\right\}$, the principal obtains X^H without paying any compensation in equilibrium.*

Proof. See the Appendix. ■

A discussion similar to the one for proposition 1 applies. Looking at Figure 2, the main difference with respect to the symmetric information case is given by the payments. Indeed the principal cannot condition on the individual actions but only on the output level.

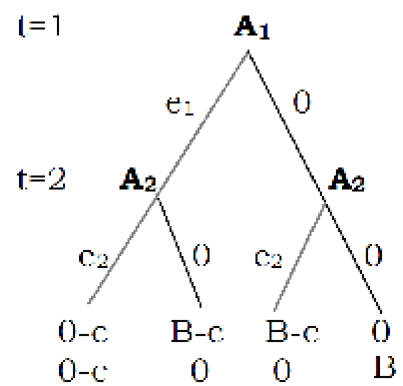

Figure 2

Consider A_2. If A_1 does not undertakes overtime, A_2 will not undertake overtime and moreover he will receive his highest monetary compensation $w_2(X^0) = B$. If A_1 undertakes overtime, A_2 has an incentive to work overtime. When A_2 is motivated by negative reciprocity, not providing overtime (allowing A_1 to gain $w_1(X^M) = B$) could be even worse than working unpaid. The negative orientation of A_2 follows from the fact that A_1, choosing to provide overtime rather to abstain, prevents him from gaining his highest monetary

[18] As, for the symmetric information case, this is only one of the several possible optimal contracts. Given the incentives provided to A_2, X^M is never produced, so depending on the value specified for $w_1(X^M) \in [0, B]$ we have different optimal compensation schemes implementing X^H at the cost equal to $2c$.

[19] Note that, since both the principal and the 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. See Macho Stadler and Perez Castrillo (2001).

compensation.
The key assumption for this result is that, while we assume the principal cannot monitor agents' actions, we still assume he is able to distinguish reciprocal workers from standard ones. This allows to offer a scheme inducing unpaid overtime under symmetric information.

The minimum level of payment[20] that the principal has to offer out of equilibrium to induce unpaid overtime is different for each agent: $\underline{B^A}$=max $\left\{ \frac{c}{\rho_1}, c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2} \right\}$. As one can easily see, $\underline{B^A}$ is increasing in the disutility of effort while decreasing in ρ. This result implies that when agents exhibit identical ρ, the agent that moves as second requires the highest minimum level of payment off equilibrium in order to undertake unpaid overtime. Finally, could be noted that, for both ρ tending to 1, the B that has to be offered off equilibrium is slightly higher than c, which is actually the standard agent' compensation. As the ρ approximate to 0, the B that has to be offered off equilibrium goes to $+\infty$

3.2.1 The less budget demanding optimal compensation scheme

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

Definition 1 *The less 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 agents undertake unpaid overtime.*

In this respect we can show that:

Proposition 3 *For any ρ_i and ρ_j, with $\rho_i > \rho_j$, a LBD optimal compensation scheme always exists and it assigns the first move to the agent j (leader) and the second move to the agent i (follower). The optimal compensation scheme is an asymmetric compensation scheme as the one described in Proposition 2.*

Proof. See the Appendix. ■

This result contains an implication for *job design* particularly useful if only limited budget are available to the principal. Since she knows the reciprocity concern of each agent, she will always convenient to assign the second move to the agent with the higher ρ the principal can offer a *LBD optimal compensation scheme* and obtain the desired outcome without paying any compensation in equilibrium.

[20]Where the index "A" allows to distinguish it from the minimum B offered under symmetric information.

4 Extensions

4.1 The Optimal Compensation Scheme with Budget Constraint

In the previous sections we assumed the principal affords a budget sufficient for inducing unpaid overtime. Denote as B^F the feasible budget. Here we analyze the case where $B^F$is lower than the level required respectively in proposition 2 and 3.

Proposition 4 *When* $0 < B^F < \underline{B} = c(\frac{1}{\min\{\rho_i,\rho_j\}}+1)$ $\left(< \underline{B}^A = \max\left\{\frac{c}{\rho_1}, c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2}\right\}\right)$, *the principal obtains* $X(\gamma, e_1, e_2)$ $\left(X^H\right)$ *by paying to the agents a sum of compensation lower than the sum of compensations paid to standard agents.*

Proof. See the appendix. ∎

The result can be explained by the *substitutability* between reciprocity concerns and monetary incentives, i.e. material payment. When $B^F \in [\underline{B}; +\infty)$, reciprocity concerns and incentives are *perfect substitutes*. Therefore, in order to induce reciprocal agents to produce $X(\gamma, e_1, e_2)$ (X^H), the principal could choose to offer the compensation scheme defined for standard agents (neutralizing in this way the ORP), *or* the compensation scheme described in Proposition 2 (3), where the production of $X(\gamma, e_1, e_2)$ (X^H) is achieved at no cost. When $0 < B^F < \underline{B}$, reciprocity concerns and monetary incentives are *imperfect substitutes*. This implies that to obtain $X(\gamma, e_1, e_2)$ (X^H) the principal must pay in equilibrium $0 < w_1(e_1, e_2) + w_2(e_1, e_2) < 2c$ $(0 < w_1(X^H) + w_2(X^H) < 2c)$. That is, even if overtime must be paid some savings can still be realized with respect to the benchmark case. Savings are increasing in the amount of the feasible budget.

4.2 Production Technology with Negative Externalities

In the previous sections we assumed a functional form not imposing any *technological interdependencies* among the agents.[21] Now consider a production technology that imposes *negative 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 overtime* exertion. Further assumption are:

1) two agents undertaking overtime are more productive than one: $X(2\gamma e - \beta e^2) > X(\gamma e) > 0$;

2) the principal maximizes her profits when only one standard agent undertakes overtime: $\Pi(\gamma, 0_i, e_j) = \Pi(\gamma, e_i, 0_j) > \Pi(\gamma, e_i, e_j) > 0$.

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

[21] 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 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).

Proposition 5 *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 principal will employ one agent, if he exhibits standard preferences, while she will form team of two agents if they are reciprocal.*

When the principal composes a team of reciprocal agents the joint overtime provision will be obtained at no cost, by offering a compensation scheme as in Proposition 2 (3). Our model complements the result by Gould and Winter (2009), which study how the effort choices of selfish workers interact depending on the technology of production. We show that reciprocity concerns represent a form of *endogenous complementarity* among the agents (Potter and Suetens, 2009) that mitigates the negative externalities imposed by the production technology.

5 Discussion

In this paper we have presented a stylized model which uses horizontal reciprocity to provide a rationale for unpaid overtime. We show that when the principal has a budget to promise credible compensations off equilibrium, she can always induce reciprocal workers to undertake productive overtime without fully compensating its cost. This result holds both under symmetric and asymmetric information. We also identify the minimal level of budget required for support a scheme inducing unpaid overtime. In addition we prove that when the principal can dispose a budget lower than such level, even paying positive monetary compensation some savings can be still realized exploiting agent's reciprocity concerns. These results can importantly affect the ideal team composition. Indeed, the principal always prefers teams of reciprocal workers rather than team with one standard and one reciprocal, and consistently, a "one standard/one reciprocal" team is always preferred to a team composed only by standard agents. We develop an extension of the basic model allowing to highlight the relevance of horizontal reciprocity in the design of incentive system characterized by a production technology imposing negative externalities among the agents. In this case the principal will demand overtime to one agent, if he is standard, while she will prefer to employ team of two agents, if they are reciprocal.

Finally, two final points need to be addressed. First, our model considers only horizontal reciprocity and does not allow for any form of *vertical* fairness. However we do not deny, as several studies suggest, that vertical reciprocity may interact with horizontal comparisons among agents in a non obvious way. Gachter et al. (2008) present experimental evidence indicating that exposure to social information about referent other weakens reciprocity response. On the contrary, combining individual wages and experimental data from a trust game conducted with workers from Ghanaians manufactories, Barr and Serneels (2009) show a positive relationship between reciprocating tendencies and productivity at both firm and individual level.

Second, the principal could demand overtime to the agent simultaneously, letting them play a *simultaneous* prisoner's dilemma, where the NE in pure strategies induces both agents to work unpaid overtime. However, we are convinced that in workplace, actual behaviors more than belief and expectation, drive the reciprocal behavior of workers. This motivate our choice of the Cox et al. (2007)'s model as reference in modeling reciprocity in sequential game reducing the stress on *beliefs* and *expectations* in the determination of agents' fairness given by the psychological game theory literature.

A Appendix

A.1 Utility for Reciprocal Agents

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

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

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 agent 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 agents, 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 agent i's utility function, and r_{i,σ_j} is the reciprocity term accounting for agent j's fairness.

A.2 Proof of Proposition 1

According to Proposition 1 the optimal compensation scheme is:

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

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

$$\begin{aligned} r_{1,\sigma_a} &= \frac{-w_1(e_1,0)+c}{w_1(e_1,0)} < 0 \\ r_{2,e} &= \frac{-w_2(0,e_2)+c}{w_2(0,e_2)} < 0 \end{aligned}$$

[22] 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.

Note that for A_1, strategies and actions coincide. On the contrary, for A_2 strategies are defined as follows: $\sigma_a = \{e, e\}$; $\sigma_b = \{e, 0\}$; $\sigma_c = \{0, e\}$ and $\sigma_d = \{0, 0\}$.

To induce both agents to undertake overtime in equilibrium, the following incentive compatibility constraints (hereafter, ICC) must hold:

$$w_1(e_1, e_2) - c + \rho_1 r_{1,\sigma_a} w_2(e_1, e_2) \geq w_1(0, e_2) + \rho_1 r_{1,\sigma_a} w_2(0, e_2), \tag{A.2.2}$$
$$w_2(e_1, e_2) - c + \rho_2 r_{2,e} w_1(e_1, e_2) \geq w_2(e_1, 0) + \rho_2 r_{2,e} w_1(e_1, 0). \tag{A.2.3}$$

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

$$0 \geq c + \rho_1(-B + c), \tag{A.2.4}$$
$$0 \geq c + \rho_2(-B + c). \tag{A.2.5}$$

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

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

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

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 overtime by both agents is more costly than the compensation scheme for standard agents. The total compensation paid to standard agents 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_a then the reciprocity of A_1 is:

$$r_{1,\sigma_a} = \frac{\max\{w_1(e_1, e_2) - c, w_1(0, e_2)\} - \max\{w_1(e_1, 0) - c, w_1(0, 0)\}}{H_1 - L_1}. \tag{A.3.1.1}$$

Since $H_1 - L_1 > 0$ then $r_{1,\sigma_a} > 0$ 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, $r_{1,\sigma_a} = \frac{w_1(0, e_2)}{w_1(0, e_2) + c} > 0$.

Similarly, reciprocity for A_2,

$$r_{2,e} = \frac{\max\{w_2(e_1, e_2) - c, w_2(e_1, 0)\} - \max\{w_2(0, e_2) - c, w_2(0, 0)\}}{H_2 - L_2}; \tag{A.3.1.2}$$

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:

$$w_1(e_1,e_2) - c + \rho_1 \frac{w_1(0,e_2)}{w_1(0,e_2)+c} w_2(e_1,e_2) \geq w_1(0,e_2) + \rho_1 \frac{w_1(0,e_2)}{w_1(0,e_2)+c} w_2(0,e_2),$$
$$w_2(e_1,e_2) - c + \rho_2 \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,e_2) \geq w_2(e_1,0) + \rho_2 \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,0).$$

By combining $1a$ and $1b$ with $2a$ and $2b$, we analyze the four possible cases where reciprocity is positive for both agents.

- 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 agents which costs $2c$.

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

$$w_1(e_1,e_2) - c - w_1(0,e_2) + \rho_1 \frac{w_1(0,e_2)}{w_1(0,e_2)+c} w_2(e_1,e_2) \geq 0 \quad ,$$
$$w_2(e_1,e_2) - c - w_2(e_1,0) + \rho_2 \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,e_2) \geq 0 \quad .$$

  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 $w_2(e_1,e_2) \geq w_2(e_1,0) + c - \rho_2 \frac{w_2(e_1,0)}{w_2(e_1,0)+c} w_1(e_1,e_2)$. By subtracting this inequality from $w_1(e_1,e_2) + w_2(e_1,e_2) < 2c$ yields $w_1(e_1,e_2)(1 - \rho_2 \frac{w_2(e_1,0)}{w_2(e_1,0)+c}) + w_2(e_1,0) - c < 0$. 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 agent 1 and 2 are respectively:

$$r_{1,\sigma_b} = \frac{\max\{w_1(X^H) - c, w_1(X^0)\} - \max\{w_1(X^M) - c, w_1(X^M)\}}{H_1 - L_1}, \quad \text{(A.3.2.1)}$$
$$r_{2,e} = \frac{\max\{w_2(X^H) - c, w_2(X^M)\} - \max\{w_2(X^M) - c, w_2(X^0)\}}{H_2 - L_2}. \quad \text{(A.3.2.2)}$$

A.4 Standard Compensation Scheme for Reciprocal Agents

A.4.1 Symmetric information case

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

$$\begin{array}{lllll} w_1(e_1,e_2){=}\ c; & w_1(e_1,0)\in[0,B]\,; & w_1(0,e_2)=0; & w_1(0,0)\in[0,B]\,; \\ w_2(e_1,e_2){=}\ c; & w_2(e_1,0)=0; & w_2(0,e_2)=c; & w_2(0,0)=0; \end{array} \quad \text{(A.4.1.1)}$$

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 agents.

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 $w_1(e_1,0)\neq c$, by substituting A.4.1.1 in the definition of reciprocity in (A.3.1.2) we obtain $r_{2,e}{=}\frac{0}{0}$.(qui va aggiunta una nota...)

A.4.2 Asymmetric information case

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

$$\begin{array}{rcl} w_1(X^H) &=& c\ \ w_1(X^M)\in[0,B]\,;\ \ w_1(X^0)=0; \\ w_2(X^H) &=& c;\ w_1(X^M)=w_1(X^0)=0; \end{array} \quad \text{(A.4.2.1)}$$

by substituting this compensation scheme in the ICCs of each agents can be shown that each action agent 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 Corollary 1

In this section we proof that the principal has the following rank over team composition: team composed by two reciprocal agents are always preferred to teams composed by a standard agent and a reciprocal agent. Consistently, this latter team composition will be always preferred over team composed by two standard agents.

A team of standard agents produce $X(\gamma,e_1,e_2)$ at a cost equal to $2c$. In subsection A.2 we show that a team of reciprocal agents produce the same output at zero cost for the principal. Let us consider the case of a team composed by a standard agent and a reciprocal agent.

Suppose $\rho_1{=}\ 0$, $\rho_2{>}\ 0$. To induce A_1 to undertake overtime a compensation scheme in (A.4.1.1) 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:

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

Since the principal wants to maximize her profit, she will offer a $w_2(e_1,e_2)$ such that the ICC holds with equality.
When $w_1(e_1, 0) - c > 0$ then A_2 will undertake *under*-paid overtime: $w_2(e_1, e_2) < c$.
When $w_1(e_1, 0) = B > c$ this will be always the case.

When $\frac{B}{B+c}(B - c) \geq \frac{c}{\rho_2}$, A_2 will provide *unpaid* overtime. In this case, the team provides X^H with a total compensation equal to c.

A.6 Proof Proposition 2

According to Proposition 2 the optimal compensation scheme is:

$$\begin{aligned} w_1(X^H) = w_1(X^0) = 0; \qquad & w_1(X^M) = B\ ; \\ w_2(X^H) = w_1(X^M) = 0; \qquad & w_1(X^0) = B. \end{aligned} \tag{A.6.1}$$

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

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

In equilibrium, to induce both agents to undertake overtime, the following ICCs must hold:

$$\begin{aligned} w_1(X^H) - c + \rho_1 r_1[w_2(X^H) - c] &\geq w_1(X^0) + \rho_1 r_1 w_2(X^0), \\ w2(X^H) - c + \rho_2 r_2 w_1(X^H) &\geq w_2(X^M) + \rho_2 r_2 w_1(X^M). \end{aligned} \tag{A.6.2}$$

By substituting (A.5.1) respectively into (A.5.2) and (A.5.3) we obtain:

$$0 \geq c + \rho_1 \frac{-w_1(X^M)}{w_1(X^M) + c}[w_2(X^0) - c] \tag{A.6.3}$$

$$0 \geq c + \rho_2 \frac{-w_2(X^0)}{w_2(X^0) + c} w_1(X^M) \tag{A.6.4}$$

Assume $w_1(X^M) = w_2(X^0) = B$. Rearranging (A.5.4) and (A.5.5) yields

$$B \ \geq \ \frac{c}{\rho_1}, \tag{A.6.5}$$

$$\frac{\rho_2}{c}B^2 - B - c \ \geq \ 0, \tag{A.6.6}$$

where $B \geq \frac{c}{\rho_1}$ is the monetary payment the principal must offer out of equilibrium in order to induce A_1 to exert unpaid overtime ($w_1(X^H) = 0$).

Solving $\frac{\rho_2}{c}B^2 - B - c = 0$ yields

$$B_1, B_2 = c\frac{[1 \pm (1 + 4\rho_2)^{\frac{1}{2}}]}{2\rho_2}\ . \tag{A.6.7}$$

Due to limited liability constraint the negative root makes no sense. Finally, the principal will offer out of equilibrium a unique level of B

$$B \geq \max\left\{\frac{c}{\rho_1}, c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2}\right\} . \tag{A.6.8}$$

A.7 Proof of Proposition 3

Here we want to prove that the LBD optimal compensation scheme assigns the second move to the agent that exhibit the highest ρ. Start from the (A.5.9) . It contains two conditions that irrespectively refer to the first and second mover: $B \geq \frac{c}{\rho_1}$ and $B \geq c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2}$.

When

$$\rho_1 = \rho_2 \Rightarrow c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2} > \frac{c}{\rho_1} . \tag{A.7.1}$$

We also know that,

$$\forall \rho_1 \neq \rho_2, \text{ if } \rho_1(1+\rho_1) \geq \rho_2 \Rightarrow c\frac{1+(1+4\rho_2)^{\frac{1}{2}}}{2\rho_2} > \frac{c}{\rho_1} . \tag{A.7.2}$$

Consider now any $\rho_i > \rho_j$. We could analyze two cases:

1) $\rho_i >> \rho_j$ such that:

1a) if the *second* move is assigned to A_i, therefore (A.6.2) is reversed: $\rho_1(1+\rho_1) < \rho_{2,}$ which implies $B \geq \frac{c}{\rho_j} > c\frac{(1+(1+4\rho_i)^{\frac{1}{2}})}{2\rho_i}$;

2a) if the *first* move is assigned to A_i, condition (A.6.2) holds: $\rho_1(1+\rho_1) \geq \rho_{2,}$ and therefore $B \geq c\frac{(1+(1+4\rho_i)^{\frac{1}{2}})}{2\rho_i} > \frac{c}{\rho_j}$.

By (A.6.1) we know that (1a) is preferred to (1b), since $\frac{c}{\rho_j} < c\frac{1+(1+4\rho_j)^{\frac{1}{2}}}{2\rho_j}$, so, in this case is better to assign the second move to A_i.

2) $\rho_i > \rho_j$ such that:

1b) if the *second* move is assigned to A_i, therefore (A.6.2) holds: $\rho_{1=j}(1+\rho_{1=j}) \geq \rho_{2=i},$ which implies $B \geq c\frac{(1+(1+4\rho_i)^{\frac{1}{2}})}{2\rho_i} > \frac{c}{\rho_j}$;

2a) if the *first* move is assigned to A_i, condition (A.6.2) holds: $\rho_{1=i}(1+\rho_{1=i}) \geq \rho_{2=j,}$ which implies $B \geq c\frac{(1+(1+4\rho_j)^{\frac{1}{2}})}{2\rho_j} > \frac{c}{\rho_i}$.

We can easily see that (1b) is preferred to (1a), since $c\frac{1+(1+4\rho_j)^{\frac{1}{2}}}{2\rho_j}$ is decreasing in ρ. So, also in this case, is better to assign the second move to A_i.

A.8 Proof of Proposition 4

In this section we want to prove that, when $B > 0$ is lower than the level inducing agents to provide unpaid overtime, the principal could always obtain overtime 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 $B^F < c\left(\frac{1}{\min\{\rho_i,\rho_j\}}+1\right)$. In this case the ICCs for A_1 and A_2 are given by:

$$w_1(e_1,e_2) \geq c-\rho_1\frac{B^F+c}{B^F-w_1(e_1,e_2)}[B^F-w_2(e_1,e_2)],$$
$$w_2(e_1,e_2) \geq c-\rho_2\frac{B^F+c}{B^F-w_2(e_1,e_2)}[B^F-w_1(e_1e_2)].$$

In order to maximizes her profit, the principal 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

$$c-\rho_1\frac{B^F+c}{B^F-w_1(e_1,e_2)}[B^F-w_2(e_1,e_2)]+c-\rho_2\frac{B^F+c}{B^F-w_2(e_1,e_2)}[B^F-w_1(e_1e_2)] < 2c,$$
$$-\rho_1\frac{B^F+c}{B^F-w_1(e_1,e_2)}[B^F-w_2(e_1,e_2)]-\rho_2\frac{B^F+c}{B^F-w_2(e_1,e_2)}[B^F-w_1(e_1e_2)] < 0$$

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

$$w_1(X^H) \geq c-\rho_1\frac{B^F}{B^F+c-w_1(X^H)}[B^F+c-w_2(X^H)]\ ,$$
$$w_2(X^H) \geq c-\rho_2\frac{B^F}{B^F+c}[B^F-w_1(X^H)].$$

The principal obtains X^H paying a sum of compensations lower than $2c$ if:

$$c-\rho_1\frac{B^F}{B^F+c-w_1(X^H)}[B^F+c-w_2(X^H)]+c-\rho_2\frac{B^F}{B^F+c}[B^F-w_1(X^H)] < 2c$$
$$-\rho_1\frac{B^F}{B^F+c-w_1(X^H)}[B^F+c-w_2(X^H)]-\rho_2\frac{B^F}{B^F+c}[B^F-w_1(X^H)] < 0$$

Since $w_1(X^H)+w_2(X^H) \leq B^F$ then the inequality is always verified.

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