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Intrinsically Motivated Agents in Teams

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Abstract: I develop a principal-agent model where a profit-maximizing principal employs two agents to undertake a project. The employees differ in terms of their intrinsic motivation towards the project and this is their private information. I analyze the impact of individual and team incentives on the screening problem of employees with different degrees of motivation within teams. If the principal conditions each agent's wage on his own level of effort (individual incentives), an increase of the rents paid to the motivated agents results in a lower level of effort exerted by all agents in the second-best. In this case, reversal incentives occur. Conversely, reversal incentives do not arise if the principal uses team-incentives. If the principal conditions each agent's wage on the effort of both agents and the agent's performance on the effort of his colleague (team-incentives), motivated agents exert the same level of effort as in the first-best.

JEL Codes: D03, D82, M54.

Keywords: Intrinsically Motivated Agents, Team Production, Adverse Selection, Individual and team incentives, Reversal Incentives.

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1 Introduction

To screen and motivate employees, firms make wide use of different forms of compensation schemes linked to their performance. The incentives may be tied for example to the individual performance or to the performance of the team. Individual incentives are intended to reward employees based on reaching individual performance goals. An example is providing compensation to a factory worker for producing a predetermined number of goods. Conversely, team incentives are designed to reward each individual in the team for a joint accomplishment. Examples of team incentives include a commission for the sale of a real estate property that is shared among the members of a sales force, and a cash bonus for a product's development that is given to a team of scientists or engineers.

While there are also other forms of compensation schemes, such as benefit-sharing and tournaments, the empirical article of Bryson et al. (2012) shows that individual incentives are very common in organizations and team-incentives have been increasingly used during the last decade. Moreover, there is a growing interest in the adoption of team incentives in the public service provision (see for instance Reilly et al., 2005, concerning the use of team incentives in the U.K. National Health Service). For these reasons, in what follows I focus on these two forms of compensation schemes and I study under what condition one outperforms the other.

In this paper, I analyze the design of optimal incentive schemes with particular interest in the screening problem of heterogeneous employees in a team. The employees differ in terms of their intrinsic motivation. Intrinsically motivated employees are interested not only in their wage but also in the project itself. Employers do not need to raise employees' compensation to align their interests because they care about the project they do. The idea that employees may derive some additional benefits from participating in a project can also be found in Delfgaauw and Dur (2008) and Prendergast (2008). In my model, the individual degree of intrinsic motivation is the agents' private information.

To investigate the design of optimal incentive schemes under adverse selection within teams, I develop a principal-agent model with multiple-agents. The principal maximizes his own profit that increases in the total amount produced. Production depends on the individual level of effort exerted by the employees (the agents) in the team. I assume the *complementarity* of the production function.

I start considering *individual incentives*. In this case, the principal conditions each agent's wage on his own level of effort. I find that intrinsically motivated agents provide a lower level of effort in the presence of asymmetric information with respect to the first-best. When individuals interact in groups and their individual rewards are affected by the actions of the others in the team, an increase in the rent paid to motivated agents results in a lower level of effort exerted by these individuals in the second-best.[1] So we are in presence of *reversal incentive*, namely situations in which an increase of rewards results in a lower effort exerted by the agents.

I study the case in which the principal offers a compensation contract that bases individual pay on the levels of effort of each member of the team and conditions individual performance on the effort of his colleagues in the team, i.e. *team incentives*. In this case, motivated agents exert the same level of effort as in the first-best. In an adverse selection model with a complementary production function, reversal incentives do not arise if the principal uses team-incentives. Moreover, the principal is better off providing team-incentives than individual incentives.

Despite these benefits, team incentives do not seem to be always used in the real world. This may be explained by the agents' attitude towards risk with respect to changes in income. If individuals are risk averse they are unwilling to be paid on the basis of the levels of effort of each member of the team. The best insurance a risk neutral principal can provide is to offer a wage to each type of agents that does not depend on the type of their colleagues in the team. However, the level of performance requested by an agent continues to depend on the performance of the other members in the team.

The remainder of the article proceeds as follows. In the next section the existing literature is reviewed; In Section 3 the general framework of the model is presented; Section 4 is devoted to the analysis of individual and team incentives under asymmetric information and Section 5 provides a discussion of the results; finally, concluding remarks are given in Section 6.

2 The Literature

A large empirical literature shows that the use of compensation schemes linked to the employees' performance is associated with improved firms' productivity (see among the others Lazear, 2000, Shearer, 2004, Bandiera et al., 2005). For this reason, the use of these forms of compensations in organizations has been the object of an increased interest among economists and policymakers (see for an overview of articles on the provision of incentives Prendergast et al., 2011).

This paper is part of a large literature on incentives in organizations using principal-multi agent models, much of which stems from the influential work of Holmstrom (1982). Papers such as Holmström and Milgrom (1990) and Itoh (1991) have pointed out that a principal can gain from collusion or coordination among his agents. Friebel and Schnedler (2011) considers the

[1]Note that this result is due to the complementarity of the production function. Therefore, it continues to hold even if agents are heterogeneous in their productivity. In Appendix A, I consider the case in which the agents are not interested in the project but they differ in productivity. However, this negative impact on the level of effort is much lower. The intuition is the following. When agents are interested in the project, they receive an additional information rent from the principal under asymmetric information. This information rent induces them to tell the truth when their colleague is motivated too but it has a negative additional impact on the effort.

effect of managers' intervention on a group of workers where workers care about co-workers' preferences because it matters for team production. They find that teams are particularly prone to negative effect of interventions. In particular, if there are complementarities in production and if the team manager has some information about team members, interventions by the manager may have destructive effects. They can distort how workers perceive their co-workers and may lead to a reduction of effort by those workers who care more about the output. These results are in line with those found in my paper when the principal offers individual incentives. However, while the authors analyze the impact of managers' interventions on the effort exerted by the agents within teams, I study the design of optimal incentives in teams and how different forms of compensation schemes impact on the screening problem of employees with different degrees of motivation.

Winter (2006) discuss the design of optimal incentives in teams and the way they are affected by the information among peers. In this literature, my results under individual incentives are in line with the findings of Winter (2009). In particular, this author studies the possibility of incentive reversal under a moral hazard setting, while I show that the same effect arises in presence of adverse selection concerns. In addition, I show that a solution to the incentive reversal problem is provided by anchoring the agent's salary and performance to those of his colleagues in the team. The possibility of incentive reversal has also been supported by Klor et al. (2011) using an experimental design.

While this literature focuses on the design of optimal incentive schemes in the presence of moral hazard concerns, I primarily interested in the screening problem of intrinsically motivated and self-interested agents. The issue of the selection of workers who are privately informed about their motivation has been studied by Heyes (2005), Delfgaauw and Dur (2007, 2008).[2] Their results are in line with the literature on psychological incentives where motivation is effective in stimulating work effort even in the absence of monetary rewards (see for example Benabou and Tirole, 2003, 2006). I find that this is indeed true under complete information on the agents' intrinsic motivation. However, this result might not hold in the presence of asymmetric information. In that case, the principal has to pay an information rent in order not to mimic selfish agents. I find that intrinsically motivated agents receive a higher wage than selfish agents. Moreover, due to the complementarity of the production function, an increase in the rent paid to motivated agents results in a lower level of effort exerted by both types of individuals in the second-best. In this case, it would be in the best interest of the principal to offer team-incentives instead of individual incentives.

This result complements the findings in the existing literature. Auriol et al. (2002), for

[2]For a multidimensional case see Barigozzi and Burani (2013). The authors study the screening problem when agents are heterogenous on their productivity and their intrinsic motivation.

example, find that the principal is better off offering team incentives when he cannot commit to long-term contracts. In particular, they show that when workers have career concerns, the principal uses team incentives to reduce the workers' incentives to sabotage their colleagues. Corts (2007) also provides a reason to use team incentives. He finds that team incentives are desirable when multi-task problems are severe. Che and Yoo (2001) find that team incentives are desirable in a repeated setting because they better allow the use of implicit punishments and rewards among peers than individual incentives.

3 The model

I consider a profit-maximizing principal (she) who employs two agents, A and B. The principal-agents relationship can be interpreted as the relationship between the owner of the firm who offers a contract in terms of wage ω_i and effort e_i with $i = A, B$ to her employees to carry out a project. The effort of each agent is observable and verifiable.
The profit function of the principal is given by:

$$\Pi = \sqrt{(e_A \;\; e_B)} - (\omega_A + \omega_B), \tag{1}$$

The principal is risk-neutral and she obtains a gross profit $f(e_A, e_B) = \sqrt{(e_A \;\; e_B)}$ with the price of the project normalized at 1. This function considers the complementarity among the levels of effort exerted by the employees. It is strictly increasing in the effort of both agents, concave and twice continuously differentiable with $f(0,0) = 0$, $f_{e_i} > 0$, $f_{e_i e_j} > 0$, and $f_{e_i e_i} < 0$ with $i, j = A, B$ and $i \neq j$.[3]

The employees are wealth constrained with zero initial wealth and they have a reservation wage of zero. The key assumption of this model is that the employees can be *intrinsically motivated*. This means that they may care not only about their wage but also about the project they have to undertake. The agents' utility function consists of their "egoistic" payoff, given by the difference between wage and effort costs, and their intrinsic motivation. The agent i's utility is:

$$V_i(\omega_i, e_i; \theta_i) = \omega_i - \frac{1}{2}e_i^2 + \theta_i \sqrt{(e_i \;\; e_j)}. \tag{2}$$

The cost of exerting effort is given by a quadratic cost function $C(e_i) = \frac{1}{2}e_i^2$. The exogenous parameter $\theta_i \geq 0$ represents agent i's intrinsic motivation with respect to the project. The employees' intrinsic motivation is their private information. There are only two types of agents: self-interested agents with $\theta_i = \underline{\theta} = 0$ and motivated agents with $\theta_i = \overline{\theta} > 0$.

The probability of high-type/low type is $\frac{1}{2}$. Agent A does not know if agent B is low-type or high-type, and viceversa. I allow types to be correlated. The conditional probability distribution

[3]Henceforth, i and j will refer to A and B and $i \neq j$.

for individual i is defined as follows:

$$\begin{aligned} \mu =& Prob(\theta_j = \overline{\theta}_j | \theta_i = \overline{\theta}_i) = Prob(\theta_j = \underline{\theta}_j | \theta_i = \underline{\theta}_i); \\ (1-\mu) =& Prob(\theta_j = \overline{\theta}_j | \theta_i = \underline{\theta}_i) = Prob(\theta_j = \underline{\theta}_j | \theta_i = \overline{\theta}_i). \end{aligned} \tag{3}$$

Then, the conditional probability of having agents of the same type is equal to μ, while that of having individuals of different type is $1-\mu$. If $\mu = \frac{1}{2}$, the types are independent, while if $\mu > \frac{1}{2}$, the types are positively correlated. Note that I assume $\mu \in (0,1)$.

The **timing of the game** is as follows. *In the initial stage* 0, each agent is informed about his own type; *in stage* 1, the principal offers a menu of contracts consisting of levels of effort and wages; *in stage* 2, agents independently decide whether to participate or not in the project. If either of them does not participate, production does not take place and the game ends. If both agents participate, the game proceeds as follows. *In stage 3*, the type of contract chosen by each agent becomes public information; *in stage* 4, the effort is exerted, the project is undertaken and wages are paid.

The assumption that the type of contract chosen by each agent becomes known before production starts is made for the following reason. This allows the principal to potentially condition each agent's wage and level of performance on those chosen by his colleague in the team. In contrast, I do not assume that the parties are able to renegotiate the contract.

All the mathematical computations and proofs of the results are in Appendix A.

In the following sections, I analyze the case in which the principal has perfect information on the agents' intrinsic motivation (Subsection 3.1) and the case in which he does not (Section 4).

3.1 The Benchmark Case

I study the optimal incentive contracts in the presence of a team-work problem in which the level of effort of each agent can affect the marginal benefit of his colleague.

With perfect information, the principal need not offer a rent to the employees because she has all the necessary information to implement the efficient levels of effort. The wage makes each agent indifferent between accepting and rejecting the contract, given the required level of effort. It just covers the cost of effort incurred by the agent minus his direct benefit derived from enjoying the project:

$$\omega_i = \frac{1}{2} e_i^2 - \theta_i \sqrt{(e_i \ e_j)}. \tag{4}$$

So the principal maximizes the following:

$$\Pi = (1 + \theta_i + \theta_j) \sqrt{(e_i \ e_j)} - \frac{1}{2} \left(e_i^2 + e_j^2 \right). \tag{5}$$

Applying the first order condition with respect to e_i and e_j, the first-best levels of effort are obtained:

$$e_i^{FB} = e_j^{FB} = \frac{1 + \theta_i + \theta_j}{2} \tag{6}$$

The left-hand side is the private marginal cost of exerting effort, while the right-hand side is the marginal benefit of exerting effort for the project. This marginal benefit consists of the marginal benefit obtained by the principal and the marginal benefit due to the individuals' intrinsic motivation. Note that agent i's level of effort is positively affected by the intrinsic motivation of his colleague. As usual, the first-best contract induces agents to exert the level of effort that maximizes the joint surplus. Hence, the resulting production levels are socially optimal.[4]

Substituting the levels of effort provided into equation (4), I obtain the optimal wages:

$$\omega_i^{FB} = \left(\frac{1 + \theta_i + \theta_j}{2}\right)\left(\frac{1 - 3\theta_i + \theta_j}{4}\right) \tag{7}$$

When the agents' intrinsic motivation lies in the following interval $\theta_i \in \left[0, \frac{1}{2}\right]$ with $i = A, B$, the employees receive a positive wage. Otherwise, due to the *limited liability condition*, the motivated agents earn a wage of 0.[5] A higher value of θ_i reduces the wage paid to agent i. This means that agents with a high intrinsic motivation receive lower incentive pay at the optimum. Take, for instance, $\theta_B > \theta_A$. In this case, the principal will offer a bigger transfer to agent A who is less interested to the project than agent B. This is because a more motivated agent exerts effort to participate in the project even if he receives a low compensation.

Proposition 1. *The levels of effort exerted by the individuals are the same, i.e.* $e_i^{FB} = e_j^{FB}$*, irrespective of their degrees of intrinsic motivation. If* $\theta_i > \theta_j$*, then* $\omega_i^{FB} < \omega_j^{FB}$*.*

Under complete information on θ, the agents' intrinsic motivation has a positive impact on the levels of effort exerted by both agents. Moreover, intrinsically motivated individuals exert a given a level of effort even if they receive a lower compensation for that. This result is in line with the existing literature where motivation is effective in stimulating work effort even in the absence of monetary rewards (see for example Benabou and Tirole, 2003, 2006).

4 Screening Problem and Compensation Schemes

In this section, I analyze the effect of different incentive pay on the employees' productivity within teams under asymmetric information. Individuals' intrinsic motivation is their private

[4] Since the participation constraints bind regardless of the agents' type, the principal extracts all the surplus above the agents' reservation utility.

[5] When $\theta_i > \frac{1}{2}$, agent i earns a rent due to his limited liability.

information but the effort is observable and verifiable. In subsection 4.1, I consider individual incentives. In this case, the principal conditions each agent's wage only on his own level of effort, i.e. $\omega_i(e_i)$. Due to the complementarity of the production function, I find that intrinsically motivated agents as well as selfish agents provide a lower level of effort compared to the first-best. We are in presence of reversal incentives. In subsection 4.2, I consider team-incentives where the principal offers a compensation contract that bases individual pay on the output of the team, $\omega_i(e_i, e_j)$, and conditions an agent's performance on the effort of his colleague, i.e. $e_i = e_i(e_j)$. In this case, motivated agents exert the same level of effort as in the first-best. In section 4, I discuss the results of these two forms of incentive pay.

4.1 Individual Incentives

I start considering the case where the principal conditions each agent's wage on his own level of effort, i.e. $\omega_i(e_i)$ with $i = A, B$. Without loss of generality, I focus on the direct revelation mechanism and to the truth-telling contracts where the agent of a certain type will choose the contract corresponding to that type.

The principal chooses a menu of contract designed for different types $\{(e_{iH}, \omega_{iH}(e_{iH})), (e_{iL}, \omega_{iL}(e_{iL}))\}$ to maximize her profit function:

$$\begin{aligned}\Pi =& \frac{\mu}{2}\left[\sqrt{(e_{iH}e_{jH})} + \sqrt{(e_{iL}e_{jL})} - \omega_{iH} - \omega_{jH} - \omega_{iL} - \omega_{jL}\right] + \\ &+ \frac{1-\mu}{2}\left[\sqrt{(e_{iH}e_{jL})} + \sqrt{(e_{iL}e_{jH})} - \omega_{iH} - \omega_{jL} - \omega_{iL} - \omega_{jH}\right]\end{aligned} \tag{8}$$

subject to incentive and participation constraints. Incentive constraints require that is optimal for each agent to report his type truthfully, while participation constraints require that each agent have to be at least as well off by participating as they would be by not participating in the project:

$$V_i(\omega_{iH}, e_{iH}; \overline{\theta}) \geq V_i(\omega_{iL}, e_{iL}; \overline{\theta}) \tag{IC_{iH}}$$

$$V_i(\omega_{iL}, e_{iL}; \underline{\theta}) \geq V_i(\omega_{iH}, e_{iH}; \underline{\theta}) \tag{IC_{iL}}$$

$$V_i(\omega_{iH}, e_{iH}; \overline{\theta}) \geq 0 \tag{PC_{iH}}$$

$$V_i(\omega_{iL}, e_{iL}; \underline{\theta}) \geq 0 \tag{PC_{iL}}$$

It is possible to reduce the number of relevant constraints (see Appendix A). As usual, I obtain that the incentive constraint for the $\overline{\theta}$-agent (IC_{iH}) is binding (because the difficulty comes from a $\overline{\theta}$-agent willing to claim that he is self-interested rather than the reverse). Under complete information the intrinsically motivated agent always receives a lower wage. Under asymmetric information, this individual can pretend to be a low type. The principal has to offer him an incentive to reveal his type. In contrast, the participation constraint for the $\underline{\theta}$-agent (PC_{iL})

is the binding one (because if a menu of contracts enables an unmotivated agent to reach his status quo utility level, it will be also the case for a motivated one).

Using the participation and the incentive constraints, the optimal wages have to satisfy the following equations if the employees are high-type and low-type, respectively:

$$\begin{aligned} \omega_{iH} =& \frac{1}{2}e_{iH}^2 - \overline{\theta}\left[\mu\sqrt{(e_{iH}e_{jH})} + (1-\mu)\sqrt{(e_{iH}e_{jL})}\right] + \underbrace{\overline{\theta}\left[\mu\sqrt{(e_{iL}e_{jH})} + (1-\mu)\sqrt{(e_{iL}e_{jL})}\right]}_{\text{Information Rent}}; \\ \omega_{iL} =& \frac{1}{2}e_{iL}^2 \end{aligned} \tag{9}$$

with $i, j = A, B$ and $i \neq j$. To induce separation of types, the principal pays an information rent to the intrinsically motivated agent. This rent is obtained through the amount of effort exerted by the agents and the magnitude of this rent is crucially affected by the parameter of asymmetric information θ. Conversely, the transfer offered to the $\underline{\theta}$-agent covers his cost of exerting effort and he does not earn any information rent.

Substituting the transfers in the principal's utility and taking the first order derivative, the levels of effort are obtained under individual incentives and the following proposition illustrates the main results.

Proposition 2. *The levels of effort exerted by both types of agents are lower under individual incentives than under complete information, i.e.* $e_{iL}^{II} < e_i^{FB}$ *and* $e_{iH}^{II} < e_i^{FB}$ *for any value of* $\overline{\theta} > 0$.

Both individuals contribute less than under complete information. This means that there is *distortion at the top and at the bottom*. When individuals interact in groups and their individual rewards are affected by the actions of the others in the team, an increase in the rent paid to motivated agents results in a lower level of effort exerted by both types of individuals in the second-best. This result is due to the complementarity of the production function and it is in line with the findings of Winter (2009).[6] The author studied the possibility of *incentive reversal* under a moral hazard setting, while I show that the same effect arises in presence of adverse selection concerns.

The intrinsic motivation has a positive impact on the level of effort exerted by motivated agents, but it has a negative impact on the level of effort exerted by selfish agents. However, this negative impact on the level of effort of the selfish agent is low when μ is low. When the composition of the team is heterogeneous, the reduction of effort by the self-interested agent is

[6]This result continues to hold even if agents are heterogeneous in their productivity. However, this negative impact on the levels of effort is much lower. In Appendix A, I consider the case in which the agents are not interested in the project and differ in their productivity.

less important. In other words, a selfish agent exerts a higher level of effort if the conditional probability of being in a team with a motivated agent is high, i.e. $1-\mu$ is high.

Substituting the levels of effort into equation (9), the wages paid in the second-best under individual incentives are obtained and the results are provided by the following proposition:

Proposition 3. *The wage paid to the motivated agent is always higher than the one paid to the selfish agent, i.e.* $\omega_{iH}^{II} > \omega_{iL}^{II}$ *for any values of* $\overline{\theta} > 0$.

Intrinsically motivated agents always receive a higher wage than selfish agents. This result goes in the opposite direction to the one found in a complete information setting. This is because motivated agents obtain an information rent in order not to mimic selfish agents. This rent depends on the degree of intrinsic motivation. When the degree of intrinsic motivation is very high, the information rent that the principal pays to motivated agents is so high that the principal can decide to exclude the low-type. However, the necessary condition for full participation, that is $e_{iL}^{II} > 0$, is always satisfied if the probability to have homogeneous individuals is sufficiently low, that is $\mu < \frac{2}{3}$. This is because μ has a negative impact on the level of effort exerted by selfish employees.

4.2 Team-Incentives

In this subsection, the principal conditions the wage on the effort of both agents, i.e. $\omega_i(e_i, e_j)$ with $i = A, B$, and each agent's effort depends on that provided by his colleague, i.e. $e_i = e_i(e_j)$ for $i, j = A, B$ and $i \neq j$. The standard revelation principle of the principal-agent theory is used and the principal chooses a menu of contract designed for different types $\{(e_{iH}(e_{jH}), e_{iH}(e_{jL}), \omega_{iH}(e_{iH}, e_{jH}), \omega_{iH}(e_{iH}, e_{jL})), (e_{iL}(e_{jH}), e_{iL}(e_{jL}), \omega_{iL}(e_{iL}, e_{jH}), \omega_{iL}(e_{iL}, e_{jL}))\}$ to maximize equation (8) subject to incentive and participation constraints. Note that under team-incentives, the incentive constraint for motivated (selfish) agents requires that the expected utility that a motivated (selfish) agent receives to be in a team has to be higher than the expected utility obtained by pretending to be selfish (motivated). In expectation a motivated (selfish) agent knows that with probability μ he will be in a team with another motivated (selfish) agent and with probability $1-\mu$ with a selfish (motivated) agent. Participation constraints guarantee that in expectation both types of agents accept the contract.

$$E_{\theta_j} V_i(\omega_{iH}, e_{iH}; \overline{\theta}) \geq E_{\theta_j} V_i(\omega_{iL}, e_{iL}; \overline{\theta}) \qquad (IC_{iH})$$

$$E_{\theta_j} V_i(\omega_{iL}, e_{iL}; \underline{\theta}) \geq E_{\theta_j} V_i(\omega_{iH}, e_{iH}; \underline{\theta}) \qquad (IC_{iL})$$

$$E_{\theta_j} V_i(\omega_{iH}, e_{iH}; \overline{\theta}) \geq 0 \qquad (PC_{iH})$$

$$E_{\theta_j} V_i(\omega_{iL}, e_{iL}; \underline{\theta}) \geq 0 \qquad (PC_{iL})$$

Again, it is possible to reduce the number of relevant constraints and I find that (IC_{iH}) and (PC_{iL}) are the binding ones.

Taking the first-order condition of equation (8) with respect to $e_{ik}(e_{jr})$ with $i, j = A, B$ and k, r can be either motivated or selfish agents, i.e. $k, r \in \{L, H\}$, the levels of effort under team-incentives are obtained and the following proposition illustrates the main results.

Proposition 4. *Under team incentives, motivated employees exert the same level of effort as in the first-best, while selfish employees exert a lower level of effort than in the first-best.*

As in the standard case where the production function is linear, there is *distortion just at the bottom.* This is an improvement with respect to individual-incentives.

Remark 1. *In an adverse selection model with a complementary production function, reversal incentives do not arise if the principal uses team-incentives.*

Concerning the choice of the team-incentives, the principal at the optimum satisfies the following equations:

$$\mu[\omega_{iH}(e_{iH}, e_{jH})] + (1-\mu)[\omega_{iH}(e_{iH}, e_{jL})] = \left[\frac{1}{2}\mu e_{iH}^2(e_{jH}) + \frac{1}{2}(1-\mu)e_{iH}^2(e_{jL})\right] + \\ -\overline{\theta}\left[\mu\sqrt{(e_{iH}\ \ e_{jH})} + (1-\mu)\sqrt{(e_{iH}\ \ e_{jL})}\right] + \overline{\theta}\left[\mu\sqrt{(e_{iL}\ \ e_{jH})} + (1-\mu)\sqrt{(e_{iL}\ \ e_{jL})}\right] \tag{10}$$

$$\mu[\omega_{iL}(e_{iL}, e_{jL})] + (1-\mu)[\omega_{iL}(e_{iL}, e_{jH})] = \left[\frac{1}{2}\mu e_{iL}^2(e_{jL}) + \frac{1}{2}(1-\mu)e_{iL}^2(e_{jH})\right] \tag{11}$$

The motivated agent receives a linear combination of wages obtained when the agent is in the team with a motivated or a selfish agent. This linear combination has to be at least equal to the sum of the cost of exerting effort minus the agent's own intrinsic motivation and plus the information rent paid to him. This rent is obtained through the amount of effort put in by the agents and the magnitude of this rent is crucially affected by the parameter of asymmetric information $\overline{\theta}$. It is also possible to notice that the rent is equal to $\overline{\theta}\left[\mu\sqrt{(e_{iL}\ \ e_{jH})} + (1-\mu)\sqrt{(e_{iL}\ \ e_{jL})}\right]$ that is the same rent found in the previous section. In contrast, the linear combination of wages paid to the selfish agent is exactly equal to the sum of the cost of exerting effort when he is in the team with a selfish or a motivated agent. The selfish agent does not earn any information rent irrespective of whether is in the team with a selfish or a motivated agent.

Remark 2. *When the agents are risk-neutral, the principal can pay any possible combination of wages that satisfy equations (10) and (11). There exist infinite solutions to this problem.*

5 Profits Comparison and Discussion

From the previous section, we have seen that when the principal offers individual incentives to her agents, the levels of effort provided by both types of agents is lower than in the first-best and we are in presence of reversal incentives. To solve this problem due to the complementarity of the production function, the principal can use team-incentives. In this case, motivated agents exert the same level of effort as in the first-best and there is distortion just at the bottom as in the standard model. In addition, the principal offers a linear combination of wages paid on the basis of the levels of effort of each member of the team.

Now, it is interesting to study in which situation the principal is better off. Comparing the profits obtained in the two cases, the principal benefits from offering team-work incentives. Graphically, Figure 1 illustrates this result.

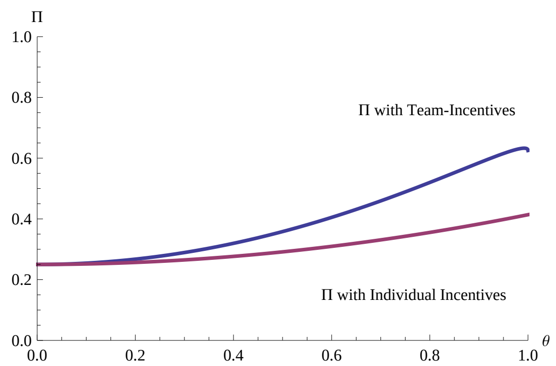

Figure 1: Profits Comparison with Individual and Team-Incentives

This is because under team-incentives the principal bases the contract on more information and, as a result, the constraints to induce the agents' participation and incentive compatibility are milder, as they must hold in expectations.

Despite these benefits, team-incentives seem not to be used in practise everywhere. A reason which may explain why individuals receive a contract that does not depend on the contract chosen by his colleague in the team is the agents' attitude towards risk with respect to income shocks. If individuals are risk averse they are unwilling to be paid on the basis of the type of contract chosen by the other member of the team. This kind of contract would introduce more risk as each agent must bear the risk of having the contract tied to the types of his colleagues about which he is uncertain. To compensate them for this increase in the risk, the principal would pay a higher wage. Then, the most efficient insurance would require that the principal offers a fixed wage to each type of agent independently of the type of his colleague in the team. To see this consider equation (10) and (11). When the agent is risk-averse the expected utility of the salary is no longer equivalent to the expected salary.

Finally, I also study under which mechanism the employees are better off. While the selfish employees do not earn any information rent and their utility is equal to 0 under individual and team incentives, the motivated employees receive a rent that depends on the levels of effort exerted by the agents in the team. Comparing the utility of the intrinsically motivated agents obtained in the two cases, the employees benefit from receiving individual incentives. This result is illustrated in Figure 2.

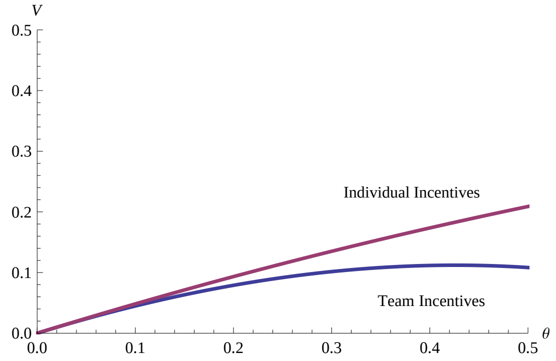

Figure 2: Intrinsically Motivated Agents' Utility with Individual and Team-Incentives for any values of $\overline{\theta}$ and $\mu = \frac{1}{2}$.

Remark 3. *The principal prefers team-incentives, while motivated employees prefer individual incentives.*

6 Conclusions

The standard economic theory argues that an increase in monetary incentives should induce agents to exert higher effort. In this paper, I have demonstrated that this result may not hold under individual incentives in a teamwork environment. In particular, when the production function is complementary, incentive reversal arises. An increase in the rent paid to motivated agents results to lower levels of effort exerted by both agents in the team. A possible solution to this problem was found in offering team-incentives to the agents instead of individual incentives. In that case, the effort provided by motivated agents coincided with the one obtained under the first-best. In addition, profits were higher under team-incentives than individual incentives. As a result, the principal is better off offering team incentives.

For future research, it would be interesting to analyse the impact of other forms of compensation schemes, such as tournaments or benefit-sharing, on the screening problem of heterogeneous employees. I am also interested in studying how the presence of other forms of agents' heterogeneity affect the optimal contract. In a recent paper, for example, I augment the standard adverse selection model by assuming that the agents suffer a utility loss whenever they feel to be worse off than their boss or/and their colleagues (see Manna, 2015). Preliminary results show that the envy towards their more productive colleagues distorts the levels of effort exerted by the low-type employees. However, when the agents are also envious towards their boss, this distortion is mitigated by the envy parameter towards their boss. Moreover, envy can make profit sharing optimal.

Finally, this simple mechanism leads to new insights concerning the design of optimal incentive schemes with particular interest in the screening problem of heterogeneous employees in a team. While in this article the focus has been on a private organization, it might also be extended to other contexts, such as a political setting and a public good provision.

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A Appendix A

A.1 Benchmark Case: Proof of Proposition 1

Under complete information, the principal maximizes the following:

$$\Pi = (1+\theta_i+\theta_j)\,(e_i\ \ e_j)^{\frac{1}{2}} - \frac{1}{2}\left(e_i^2+e_j^2\right) \tag{12}$$

Applying the first order condition with respect to e_i and e_j, I obtain the following system of equations:

$$\begin{cases} \frac{\partial \Pi}{\partial e_i} : \frac{1}{2}\left(e_i e_j\right)^{\frac{1}{2}} e_j (1+\theta_i+\theta_j) = e_i \\ \\ \frac{\partial \Pi}{\partial e_j} : \frac{1}{2}\left(e_i e_j\right)^{\frac{1}{2}} e_i (1+\theta_i+\theta_j) = e_j \end{cases}$$

Solving the system of equations, the first-best levels of effort are obtained:

$$e_i^{FB} = e_j^{FB} = \frac{1+\theta_i+\theta_j}{2} \tag{13}$$

The wages are equal to:

$$\omega_i = \frac{1}{2}e_i^2 - \theta_i(e_i\ \ e_j)^{\frac{1}{2}} \quad \text{and} \quad \omega_j = \frac{1}{2}e_j^2 - \theta_j(e_i\ \ e_j)^{\frac{1}{2}}. \tag{14}$$

Substituting the first-best levels of effort into equation (14), I obtain that:

$$\omega_i^{FB} > \omega_j^{FB} \ \text{ if } \ \frac{1}{2}\left(\frac{1+\theta_i+\theta_j}{2}\right)^2 - \theta_i\left(\frac{1+\theta_i+\theta_j}{2}\right) > \frac{1}{2}\left(\frac{1+\theta_i+\theta_j}{2}\right)^2 - \theta_j\left(\frac{1+\theta_i+\theta_j}{2}\right)$$

After some simple computations, it is possible to notice that $\omega_i^{FB} > \omega_j^{FB}$ if $\theta_i < \theta_j$.

A.2 Which Are the Binding Constraints?

I want to show that the incentive constraint for the $\overline{\theta}$-agent is binding, while the participation constraint of the $\underline{\theta}$-agent is the binding one.

Proof. I have the following incentive and participation constraints for individual i:

$$\omega_{iH} - \frac{1}{2}e_{iH}^2 + \overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}} + (1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right] \geq \omega_{iL} - \frac{1}{2}e_{iL}^2 + \overline{\theta}\left[\mu(e_{iL}e_{jH})^{\frac{1}{2}} + (1-\mu)(e_{iL}e_{jL})^{\frac{1}{2}}\right] \tag{IC_{iH}}$$

$$\omega_{iL} - \frac{1}{2}e_{iL}^2 \geq \omega_{iH} - \frac{1}{2}e_{iH}^2 \tag{IC_{iL}}$$

$$\omega_{iH} - \frac{1}{2}e_{iH}^2 + \overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}} + (1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right] \geq 0 \tag{PC_{iH}}$$

$$\omega_{iL} - \frac{1}{2}e_{iL}^2 \geq 0 \tag{PC_{iL}}$$

Let's determine which constraints bind.

First, note that if equations (IC_{iH}) and (PC_{iL}) are satisfied, then

$$\omega_{iH}-\frac{1}{2}e_{iH}^2+\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right]\geq\overline{\theta}\left[\mu(e_{iL}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iL}e_{jL})^{\frac{1}{2}}\right]\geq 0 \quad (15)$$

Equation (15) reflects the fact that a motivated agent receives more surplus from the project than a self-interested agent. The participation constraint for the intrinsically motivated agent:

$$\omega_{iH}-\frac{1}{2}e_{iH}^2+\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right]\geq 0$$

is satisfied as well. Furthermore, it will not be binding because $\overline{\theta}\left[\mu(e_{iL}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iL}e_{jL})^{\frac{1}{2}}\right]\geq 0$ has to be satisfied as well. In contrast, the participation constraint for the low-type must be binding.

Next, the incentive compatibility constraint for the high-type must be binding, that is:

$$\omega_{iH}=\frac{1}{2}e_{iH}^2-\overline{\theta}\left[\mu\left(e_{iH}e_{jH}\right)^{\frac{1}{2}}+(1-\mu)\left(e_{iH}e_{jL}\right)^{\frac{1}{2}}\right]+\overline{\theta}\left[\mu\left(e_{iL}e_{jH}\right)^{\frac{1}{2}}+(1-\mu)\left(e_{iL}e_{jL}\right)^{\frac{1}{2}}\right]$$

If this incentive were not binding, the principal could increase ω_{iH} slightly and keep all constraints satisfied. And the incentive constraint for the low-type, that is

$$\omega_{iL}\geq\frac{1}{2}e_{iL}^2-\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right]$$

cannot be binding given that $\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right]\geq 0$ has to be satisfied. □

A.3 Proof of Proposition 2

In this subsection, I show that the levels of effort exerted by both types of agents under individual incentives are lower than under the first-best. In mathematical terms, this means that $e_{iL}^{II}<e_i^{FB}$ and $e_{iH}^{II}<e_i^{FB}$ for any values of $\overline{\theta}>0$ and $\mu>0$.

The principal chooses the contract $\{e_{iH},e_{iL},\omega_{iH}(e_{iH}),\omega_{iL}(e_{iL})\}$ to maximize equation (8) subject to the incentive constraint for the high-type, the participation constraint of the low-type and non negativity conditions on the levels of effort. The Lagrangian for this problem is:

$$\begin{aligned}L=&\frac{\mu}{2}\left[(e_{iH}e_{jH})^{\frac{1}{2}}+(e_{iL}e_{jL})^{\frac{1}{2}}\right]+\frac{1-\mu}{2}\left[(e_{iH}e_{jL})^{\frac{1}{2}}+(e_{iL}e_{jH})^{\frac{1}{2}}\right]-\frac{1}{2}\left[\omega_{iH}+\omega_{jH}+\omega_{iL}+\omega_{jL}\right]+\\&+\lambda_1\left[\omega_{iH}-\frac{1}{2}e_{iH}^2+\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iH}e_{jL})^{\frac{1}{2}}\right]-\overline{\theta}\left[\mu(e_{iL}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iL}e_{jL})^{\frac{1}{2}}\right]\right]+\\&+\lambda_1\left[\omega_{jH}-\frac{1}{2}e_{jH}^2+\overline{\theta}\left[\mu(e_{iH}e_{jH})^{\frac{1}{2}}+(1-\mu)(e_{iL}e_{jH})^{\frac{1}{2}}\right]-\overline{\theta}\left[\mu(e_{iH}e_{jL})^{\frac{1}{2}}+(1-\mu)(e_{iL}e_{jL})^{\frac{1}{2}}\right]\right]+\\&+\lambda_2\left[\omega_{iL}-\frac{1}{2}e_{iL}^2+\omega_{jL}-\frac{1}{2}e_{jL}^2\right]\end{aligned} \quad (16)$$

The first-order conditions are:

$$\begin{cases} \frac{\partial L}{\partial \omega_{iH}} = \frac{\partial L}{\partial \omega_{jH}} : -\frac{1}{2} + \lambda_1 = 0 \\ \frac{\partial L}{\partial \omega_{iL}} = \frac{\partial L}{\partial \omega_{jL}} : -\frac{1}{2} + \lambda_2 = 0 \\ \frac{\partial L}{\partial e_{iH}} : \frac{1}{2}\mu(1+2\overline{\theta})\,(e_{iH}e_{jH})^{\frac{1}{2}}\,e_{jH} + \frac{1}{2}[(1-\mu)(1+\overline{\theta}) - \mu\overline{\theta}]\,(e_{iH}e_{jL})^{\frac{1}{2}}\,e_{jL} = e_{iH} \\ \frac{\partial L}{\partial e_{jL}} : \frac{1}{2}[\mu(1+2\overline{\theta}) - 2\overline{\theta}]\,(e_{iL}e_{jL})^{\frac{1}{2}}\,e_{iL} + \frac{1}{2}[(1-\mu)(1+\overline{\theta}) - \mu\overline{\theta}]\,(e_{iH}e_{jL})^{\frac{1}{2}}\,e_{iH} = e_{jL} \\ \frac{\partial L}{\partial e_{jH}} : \frac{1}{2}\mu(1+2\overline{\theta})\,(e_{iH}e_{jH})^{\frac{1}{2}}\,e_{iH} + \frac{1}{2}[(1-\mu)(1+\overline{\theta}) - \mu\overline{\theta}]\,(e_{iL}e_{jH})^{\frac{1}{2}}\,e_{iL} = e_{jH} \\ \frac{\partial L}{\partial e_{iL}} : \frac{1}{2}[\mu(1+2\overline{\theta}) - 2\overline{\theta}]\,(e_{iL}e_{jL})^{\frac{1}{2}}\,e_{jL} + \frac{1}{2}[(1-\mu)(1+\overline{\theta}) - \mu\overline{\theta}]\,(e_{iL}e_{jH})^{\frac{1}{2}}\,e_{jH} = e_{iL} \end{cases}$$

It is possible to notice that $\lambda_1 = \lambda_2 = \frac{1}{2}$. Let $A = \frac{1}{2}[\mu(1+2\overline{\theta})]$, $B = \frac{1}{2}[(1-\mu)(1+\overline{\theta}) - \mu\overline{\theta}]$ and $C = \frac{1}{2}[\mu(1+2\overline{\theta}) - 2\overline{\theta}] = A - \overline{\theta}$, it is possible to rewritten the system of equation in the following way:

$$\begin{cases} \frac{\partial L}{\partial e_{iH}} : A\,(e_{iH}e_{jH})^{\frac{1}{2}}\,e_{jH} + B\,(e_{iH}e_{jL})^{\frac{1}{2}}\,e_{jL} = e_{iH} \\ \frac{\partial L}{\partial e_{jH}} : A\,(e_{iH}e_{jH})^{\frac{1}{2}}\,e_{iH} + B\,(e_{iL}e_{jH})^{\frac{1}{2}}\,e_{iL} = e_{jH} \\ \frac{\partial L}{\partial e_{iL}} : C\,(e_{iL}e_{jL})^{\frac{1}{2}}\,e_{jL} + B\,(e_{iL}e_{jH})^{\frac{1}{2}}\,e_{jH} = e_{iL} \\ \frac{\partial L}{\partial e_{jL}} : C\,(e_{iL}e_{jL})^{\frac{1}{2}}\,e_{iL} + B\,(e_{iH}e_{jL})^{\frac{1}{2}}\,e_{iH} = e_{jL} \end{cases}$$

When $A = C$, $e_{iH} = e_{iL} = \frac{1}{2}(1+\overline{\theta}) < \frac{1}{2}(1+2\overline{\theta}) = e_i^{FB}$. This would be the best I could get under second-best and, in any case, it would be lower than the result obtained in the first-best when both agents are motivated. However, $A = C$ if $\overline{\theta} = 0$ that it is never the case. When $A \neq C$ $e_{iH}^{II} \in \left(\frac{1}{2}, \frac{1}{2}(1+\overline{\theta})\right]$ and $e_{iL}^{II} = \left[\frac{1}{2}(1-\overline{\theta}), \frac{1}{2}\right)$. Proposition 2 is satisfied for any values of $\overline{\theta}$.

A.4 Proof of Proposition 3

I want to prove that $\omega_{iH}^{II} > \omega_{iL}^{II}$ for any values of $\overline{\theta}$. In the previous subsection, I have found that the levels of effort exerted by both types of individuals are in the intervals specified above. An increase of the levels effort has a positive impact on the wages. In order to prove that $\omega_{iH}^{II} > \omega_{iL}^{II}$, I consider the extreme case in which motivated agents exert their lowest level of effort while unmotivated agents their highest. If the inequality holds in this extreme case, it always holds.

The lowest level of effort exerted by motivated agents is $e_{iH} = \frac{1}{2} + \epsilon$ while the highest level of effort exerted by unmotivated agents is $e_{iL} = \frac{1}{2} - \epsilon$ where ϵ tends to 0. Substituting these values into equation (9), I obtain that $\omega_{iL}^{II} < \omega_{iH}^{II}$ if

$$\underbrace{\frac{1}{2}\left(\frac{1}{2}-\epsilon\right)^2}_{\omega_{iL}^{II}\left(e_{iL}=\frac{1}{2}-\epsilon\right)} < \underbrace{\frac{1}{2}\left(\frac{1}{2}+\epsilon\right)^2 - \overline{\theta}\left[\mu\left(\frac{1}{2}+\epsilon\right) + (1-2\mu)\left(\left(\frac{1}{2}+\epsilon\right)\left(\frac{1}{2}-\epsilon\right)\right)^{\frac{1}{2}}\right] + \overline{\theta}\left[(1-\mu)\left(\frac{1}{2}-\epsilon\right)\right]}_{\omega_{iH}^{II}\left(e_{iH}=\frac{1}{2}+\epsilon\right)}$$

This is indeed true if

$$\overline{\theta} > -\frac{2\epsilon}{(1-2\mu)(-1+\sqrt{1-4\epsilon^2}+2\epsilon)}$$

That is always the case for ϵ that tends to 0. I have proved that the inequality holds in this extreme case and, as a result, it always holds.

A.5 Team-Incentives and Proof of Proposition 4

The expected utility that a motivated agent receives to be in a team with a motivated agent with probability μ or with a self-interested agent with probability $1-\mu$ has to be higher than the expected utility obtained by pretending to be selfish. In the same way, the expected utility that a selfish agent receives to be in a team with a selfish agent with probability μ or with a motivated agent with probability $1-\mu$ has to be higher than the expected utility obtained by pretending to be motivated.[7] The incentive constraints for motivated and selfish individuals are respectively equal to:

$$\mu\left[\omega_{iH}(e_{iH},e_{jH})-\frac{1}{2}e_{iH}^2(e_{jH})+\overline{\theta}(e_{iH}e_{jH})^{\frac{1}{2}}\right]+(1-\mu)\left[\omega_{iH}(e_{iH},e_{jL})-\frac{1}{2}e_{iH}^2(e_{jL})+\overline{\theta}(e_{iH}e_{jL})^{\frac{1}{2}}\right]$$
$$\geq\mu\left[\omega_{iL}(e_{iL},e_{jH})-\frac{1}{2}e_{iL}^2(e_{jH})+\overline{\theta}(e_{iL}e_{jH})^{\frac{1}{2}}\right]+(1-\mu)\left[\omega_{iL}(e_{iL},e_{jL})-\frac{1}{2}e_{iL}^2(e_{jL})+\overline{\theta}(e_{iL}e_{jL})^{\frac{1}{2}}\right]$$

$$\mu\left[\omega_{iL}(e_{iL},e_{jL})-\frac{1}{2}e_{iL}^2(e_{jL})\right]+(1-\mu)\left[\omega_{iL}(e_{iL},e_{jH})-\frac{1}{2}e_{iL}^2(e_{jH})\right]$$
$$\geq\mu\left[\omega_{iH}(e_{iH},e_{jL})-\frac{1}{2}e_{iH}^2(e_{jL})\right]+(1-\mu)\left[\omega_{iH}(e_{iH},e_{jH})-\frac{1}{2}e_{iH}^2(e_{jH})\right]$$

The participation constraints for motivated and selfish individuals are respectively equal to:

$$\mu\left[\omega_{iH}(e_{iH},e_{jH})-\frac{1}{2}e_{iH}^2(e_{jH})+\overline{\theta}(e_{iH}e_{jH})^{\frac{1}{2}}\right]+(1-\mu)\left[\omega_{iH}(e_{iH},e_{jL})-\frac{1}{2}e_{iH}^2(e_{jL})+\overline{\theta}(e_{iH}e_{jL})^{\frac{1}{2}}\right]\geq 0$$

$$\mu\left[\omega_{iL}(e_{iL},e_{jL})-\frac{1}{2}e_{iL}^2(e_{jL})\right]+(1-\mu)\left[\omega_{iL}(e_{iL},e_{jH})-\frac{1}{2}e_{iL}^2(e_{jH})\right]\geq 0$$

Again, the incentive constraint for the $\overline{\theta}$-agent is binding. The $\overline{\theta}$-agent can be willing to claim that he is selfish. At the same time, the participation constraint for the $\underline{\theta}$-agent is the binding one. If the contract satisfies the participation constraint of the selfish agent, it will also satisfy the participation constraint of the motivated agent. The proof of these results is similar

[7]Remember that μ is the conditional probability of having individuals of the same type in the team.

to the one provided for individual incentives. The Lagrangian of this problem is:

$$L=\frac{\mu}{2}\left[\sqrt{(e_{iH}e_{jH})}+\sqrt{(e_{iL}e_{jL})}-\omega_{iH}(e_{iH},e_{jH})-\omega_{jH}(e_{iH},e_{jH})-\omega_{iL}(e_{iL},e_{jL})-\omega_{jL}(e_{iL},e_{jH})\right]+$$
$$+\frac{1-\mu}{2}\left[\sqrt{(e_{iH}e_{jL})}+\sqrt{(e_{iL}e_{jH})}-\omega_{iH}(e_{iH},e_{jL})-\omega_{jL}(e_{iH},e_{jL})-\omega_{iL}(e_{iL},e_{jH})-\omega_{jH}(e_{iL},e_{jH})\right]+$$
$$+\lambda_1\left\{\mu\left[\omega_{iH}(e_{iH},e_{jH})-\frac{1}{2}e^2_{iH}(e_{jH})+\overline{\theta}\sqrt{(e_{iH}e_{jH})}\right]+(1-\mu)\left[\omega_{iH}(e_{iH},e_{jL})-\frac{1}{2}e^2_{iH}(e_{jL})+\overline{\theta}\sqrt{(e_{iH}e_{jL})}\right]\right\}+$$
$$+\lambda_1\left\{\mu\left[\omega_{jH}(e_{iH},e_{jH})-\frac{1}{2}e^2_{jH}(e_{iH})+\overline{\theta}\sqrt{(e_{iH}e_{jH})}\right]+(1-\mu)\left[\omega_{jH}(e_{iL},e_{jH})-\frac{1}{2}e^2_{jH}(e_{iL})+\overline{\theta}\sqrt{(e_{iL}e_{jH})}\right]\right\}-$$
$$-\lambda_1\left\{\mu\left[\omega_{iL}(e_{iL},e_{jH})-\frac{1}{2}e^2_{iL}(e_{jH})+\overline{\theta}\sqrt{(e_{iL}e_{jH})}\right]+(1-\mu)\left[\omega_{iL}(e_{iL},e_{jL})-\frac{1}{2}e^2_{iL}(e_{jL})+\overline{\theta}\sqrt{(e_{iL}e_{jL})}\right]\right\}+$$
$$-\lambda_1\left\{\mu\left[\omega_{jL}(e_{iH},e_{jL})-\frac{1}{2}e^2_{jL}(e_{iH})+\overline{\theta}\sqrt{(e_{iH}e_{jL})}\right]+(1-\mu)\left[\omega_{jL}(e_{iL},e_{jL})-\frac{1}{2}e^2_{jL}(e_{iL})+\overline{\theta}\sqrt{(e_{iL}e_{jL})}\right]\right\}$$

$$+\lambda_2\left\{\mu\left[\omega_{iL}(e_{iL},e_{jL})-\frac{1}{2}e^2_{iL}(e_{jL})\right]+(1-\mu)\left[\omega_{iL}(e_{iL},e_{jH})-\frac{1}{2}e^2_{iL}(e_{jH})\right]\right\}+$$
$$+\lambda_2\left\{\mu\left[\omega_{jL}(e_{iL},e_{jL})-\frac{1}{2}e^2_{jL}(e_{iL})\right]+(1-\mu)\left[\omega_{jL}(e_{iH},e_{jL})-\frac{1}{2}e^2_{jL}(e_{iH})\right]\right\}$$

The first-order conditions are:

$$\begin{cases}
\frac{\partial L}{\partial \omega_{iH}(e_{iH},e_{jH})}: -\frac{\mu}{2}+\lambda_1\mu=0\Rightarrow\lambda_1=\frac{1}{2}\\
\frac{\partial L}{\partial \omega_{iH}(e_{iH},e_{jL})}: -\frac{1-\mu}{2}+\lambda_1(1-\mu)=0\Rightarrow\lambda_1=\frac{1}{2}\\
\frac{\partial L}{\partial \omega_{iL}(e_{iL},e_{jH})}: -\frac{1-\mu}{2}-\lambda_1\mu+\lambda_2(1-\mu)=0\Rightarrow\lambda_2=\frac{1}{2(1-\mu)}\\
\frac{\partial L}{\partial \omega_{iL}(e_{iL},e_{jL})}: -\frac{\mu}{2}-\lambda_1(1-\mu)+\lambda_2\mu=0\Rightarrow\lambda_2=\frac{1}{2\mu}\\
\frac{\partial L}{\partial e_{iH}(e_{jH})}: e_{iH}(e_{jH})=\frac{e_{jH}}{2\sqrt{(e_{iH}e_{jH})}}(1+2\overline{\theta})=e^{FB}_{iH}(e_{jH})\\
\frac{\partial L}{\partial e_{iH}(e_{jL})}: e_{iH}(e_{jL})=\frac{e_{jL}}{2\sqrt{(e_{iH}e_{jL})}}(1+\overline{\theta})=e^{FB}_{iH}(e_{jL})\\
\frac{\partial L}{\partial e_{iL}(e_{jH})}: e_{iL}(e_{jH})=\frac{e_{jH}}{2\sqrt{(e_{iL}e_{jH})}}(1-\overline{\theta})<e^{FB}_{iL}(e_{jH})\\
\frac{\partial L}{\partial e_{iL}(e_{jL})}: e_{iL}(e_{jL})=\frac{e_{jL}}{2\sqrt{(e_{iL}e_{jL})}}(1-2\overline{\theta})<e^{FB}_{iL}(e_{jL})
\end{cases}$$

Solving the system of equations, the levels of effort exerted by the agents are obtained. I find that motivated agents exert the same level of effort as in the first-best, while selfish agents exert a lower level of effort.

A.6 Heterogeneity in their Productivity

As an extension, I consider the case in which agents do not care about the project but they differ in their productivity. In particular, I am interested in the impact of differences in the employees' productivity on their effort under *individual incentives.* I find that, even in this case, both types of agents provide a lower level of effort than in the first-best. However, this negative impact on effort is much lower than the one found when agents differ in their intrinsic motivation.

The principal maximizes the profit function in equation (1), while agent i' s utility function is:

$$V_i' = \omega_i - \frac{1}{2}\alpha_i e_i^2 \tag{17}$$

where the exogenous parameter α_i is agent i's cost of production.

Under complete information, the principal maximizes the following:

$$\Pi = \sqrt{(e_i e_j)} - \frac{1}{2}(\alpha_i e_i + \alpha_j e_j) \tag{18}$$

Applying the first order condition, I obtain the first-best levels of effort:

$$e_i^{FB} = \left[\frac{1}{2\alpha_i^{3/4}\alpha_j^{1/4}}\right]; \; e_j^{FB} = \left[\frac{1}{2\alpha_j^{3/4}\alpha_i^{1/4}}\right]. \tag{19}$$

Of course an increase of the agent i's cost of production has a negative impact on his own level of effort. Moreover, the agent i's level of effort is negatively affected by the cost of production of his colleague α_j but the impact is lower than the one of α_i.

Now, I consider the case in which employees' productivity is their private information. For simplicity, employees can have only two types of abilities: efficient agent with a low cost $\alpha_i = \underline{\alpha}$ and inefficient agent with $\alpha_i = \overline{\alpha}$ with $\overline{\alpha} > \underline{\alpha}$. Each agent does not know the type of his colleague in the team. The conditional probability distribution for individual i is as follows:

$$\begin{aligned} v =& Prob(\alpha_j = \overline{\alpha}_j | \alpha_i = \overline{\alpha}_i) = Prob(\alpha_j = \underline{\alpha}_j | \alpha_i = \underline{\alpha}_i); \\ (1-v) =& Prob(\alpha_j = \overline{\alpha}_j | \theta_i = \underline{\alpha}_i) = Prob(\alpha_j = \underline{\alpha}_j | \alpha_i = \overline{\alpha}_i). \end{aligned} \tag{20}$$

The conditional probability of having agents of the same type is equal to v, while that of having individuals of different type is $1 - v$.

The principal offers different contracts designed for different types and maximizes the following:

$$\begin{aligned} \max_{e_{iH}, \omega_{iH}, e_{iL}, \omega_{iL}} =& \frac{v}{2}\left[f(e_{iH}, e_{jH}) + f(e_{iL}, e_{jL})\right] + \frac{1-\mu}{2}\left[f(e_{iH}, e_{jL}) + f(e_{iL}, e_{jH})\right] + \\ &- \frac{1}{2}\left[\omega_{iH} + \omega_{jH} + \omega_{iL} + \omega_{jL}\right] \end{aligned} \tag{21}$$

subject to the incentive constraint of the efficient agent and the participation constraint of the inefficient one.

$$\begin{aligned} \omega_{iH} =& \frac{1}{2}\underline{\alpha} e_{iH}^2 + \frac{1}{2}(\overline{\alpha} - \underline{\alpha}) e_{iL}^2; \\ \omega_{iL} =& \frac{1}{2}\overline{\alpha} e_{iL}^2 \end{aligned} \tag{22}$$

To induce separation of types, the principal pays an information rent to the efficient agent that is equal to $\frac{1}{2}(\triangle\alpha)e_{iL}^2$.

Substituting the transfers in the principal's utility and taking the first order derivative, the levels of effort have to satisfy the following equations:

$$\begin{aligned} \underline{\alpha} e_{iH} &= v f'(e_{iH}, e_{jH}) + (1-v) f'(e_{iH}, e_{jL}) \\ (2\overline{\alpha} - \underline{\alpha}) e_{iL} &= v f'(e_{iL}, e_{jL}) + (1-v) f'(e_{iL}, e_{jH}) \end{aligned} \tag{23}$$

The information rent does not affect directly the level of effort of the efficient agent but indirectly through a reduction of the effort put in by the inefficient agent. Even in this case, both individuals contribute less than under complete information. However, this negative impact on the levels of effort is much lower. In order to see that, I compare the results obtained by the two forms of heterogeneity. When agents are heterogenous in their intrinsic motivation, the levels of effort have to satisfy the following equations:

$$\begin{aligned} e_{iH} &= \mu f'(e_{iH}, e_{jH})(1 + 2\overline{\theta}) + (1-\mu) f'(e_{iH}, e_{jL})(1 + \overline{\theta}) \boxed{-\mu\overline{\theta}[f'(e_{iH}, e_{jL})]} \\ e_{iL} &= \mu f'(e_{iL}, e_{jL}) + (1-\mu) f'(e_{iL}, e_{jH})(1 + \overline{\theta}) \boxed{-2(1-\mu)\overline{\theta}[f'(e_{iL}, e_{jL})]} \end{aligned} \tag{24}$$

When agents are interested in the project, they receive an additional information rent from the principal. This information rent induces them to tell the truth on their types and it has a negative impact on the effort of both types of agents. The motivated agent reduces his level of effort proportionally to the loss he obtains when his colleague pretends to be selfish when instead he is motivated too, i.e. $-\mu\overline{\theta}[f'(e_{iH}, e_{jL})]$. The selfish agent reduces his level of effort proportionally to twice the loss obtained by pretending to be low-type when his colleague is low-type too, i.e. $-2(1-\mu)\overline{\theta}[f'(e_{iL}, e_{jL})]$. As a result, reversal incentives are stronger when agents are heterogenous in their intrinsic motivation than in their productivity.