

Subjective Evaluation Contracts for Overconfident Workers

Matteo Foschi, *Charles River Associates*

Luís Santos-Pinto, *Faculty of Business and Economics, University of Lausanne**

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Abstract

This paper analyzes the impact of worker overconfidence on the design of optimal subjective evaluation contracts. An overconfident worker either overestimates the probability of success of the project (overestimation) or believes his private performance evaluation is more informative than it actually is (overprecision). The paper derives four main results. First, overestimation changes the firm's optimal subjective evaluation contract. Second, overestimation can lead to exploitation. Third, overprecision can lead the firm to offer a subjective evaluation contract that uses the worker's performance evaluation as an input to set compensation. Fourth, overprecision can lead to either a Pareto improvement or exploitation.

JEL Codes: D82; D84; D86; J41; J7.

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1 Introduction

Most workers perform jobs in which objective performance measures are extremely difficult to obtain (Prendergast, 1999). Very often, the ultimate quality of a worker's performance, output or service is either not directly observable or it is only observable in a distant future but the worker has to be paid today. This happens in the production of complex goods and services like technological gadgets, software programs, movies, or academic research papers. In these types of jobs, firms typically provide work incentives by offering contracts which use subjective measures of performance like, for example, evaluations of supervisors, co-workers, or consumers.

Experimental evidence shows that most people are overconfident. Overconfidence is a well documented psychological bias that is important in investment and financial decisions (Russo and Schoemaker 1992, Malmendier and Tate 2005, 2008, and Malmendier et al. 2011). Firms try to exploit consumer overconfidence in goods markets (DellaVigna and Malmendier 2006, Grubb 2009, DellaVigna 2009). Overconfidence also has consequences for economic behavior in labor markets (Spinnewijn 2013, Spinnewijn 2015, Kőszegi 2014, Santos-Pinto and de la Rosa 2020). Sautmann (2013) conducts a laboratory experiment that finds support for the prediction that firms can use objective evaluation contracts to exploit overconfident workers.

The absence of objective performance measures creates a natural environment in which overconfidence may influence economic behavior in labor markets.¹ This paper asks how worker overconfidence affects employment relationships governed by subjective evaluation contracts. Is there a way for a firm to take advantage of a worker's overconfidence? Does the worker lose or gain from being overconfident? How does worker overconfidence affect social welfare? The paper provides precise answers to these questions.

Our setting is a principal-agent contractual environment with hidden action and

¹Felson (1981) and Dunning et al. (1989) show empirically that the more ambiguous or subjective is the definition of an ability, the more individuals are overconfident. Van Den Steen (2004), Santos-Pinto and Sobel (2005), and Van den Steen (2011) provide mechanisms whereby an increase in subjectivity raises overconfidence.

subjective evaluation. A risk neutral firm (or principal) hires a risk neutral worker (or agent) protected by limited liability to carry out a project. The firm offers a one-period subjective evaluation contract to the worker. If the worker accepts the contract, he chooses an effort level – high or low – to exert towards the realization of a project that may or may not be successful. The probability the project succeeds is larger under high effort and the worker’s effort cost of high effort is larger than of low effort.

The worker’s effort choice as well as the project’s performance are neither observable nor contractible. However, the project’s performance generates separate, private (and hence subjective) performance evaluation signals for the firm and the worker. These signals represent the parties’ opinion about the project’s performance. Each signal has only two possible realizations: acceptable and unacceptable performance. The firm’s signal is more informative than the worker’s, that is, the firm is the expert. The signals are positively correlated and the extent to which performance evaluations are subjective depends on the signals’ degree of positive correlation. After privately observing their signal realizations, the firm and the worker make their performance evaluation reports simultaneously and independently. Finally, payoffs are realized according to the contract.

According to Moore and Healy (2008) there are three main types of overconfidence: (1) people tend to overestimate their absolute skills (overestimation), (2) they tend to display excessive confidence in the precision of their private information (overprecision or miscalibration), and (3) they tend to overplace themselves relative to others (overplacement or the “better-than-average” effect). We study overestimation and overprecision since we focus on contracts for a single worker. A worker displays overestimation when he believes the probability of success of the project for any effort level is higher than it actually is. A worker displays overprecision when he believes his private performance evaluation is more informative than it actually is. The firm is fully informed about the worker’s bias.

In this set-up, a subjective evaluation contract specifies a compensation for the

worker and a wage cost for the firm under each possible pair of performance evaluations reports. The compensation is the dollar amount the worker receives and the wage cost is the firm's dollar cost of employing the worker. The analysis focuses on the optimal subjective evaluation contract that incentivizes high effort. This is the most realistic and interesting case. In our context, the optimal contract for a rational worker replicates MacLeod's (2003): the worker's compensation only depends on the firm's performance evaluation report, the firm's wage cost depends on both reports, and the worker receives a high compensation when the firm reports an acceptable performance and a low compensation otherwise.

The key findings are as follows. First, overestimation changes the optimal contract offered to the worker. When overestimation makes high effort more attractive, the firm lowers compensation in states where the firm reports an acceptable performance and either keeps compensation unchanged (if the worker's outside option is small) or raises it (if the worker's outside option is large) in states where the firm reports an unacceptable performance. In contrast, when overestimation makes high effort less attractive, the firm raises compensation in states where the firm reports an acceptable performance and either keeps compensation unchanged (if the worker's outside option is small) or raises it (if the worker's outside option is large) in states where the firm reports an unacceptable performance.

Second, worker overestimation can make the firm better off and the worker worse off, leading to exploitation. This depends on the participation, incentive, and truth telling effects of overestimation. The participation effect is the impact of overestimation on the worker's willingness to accept the contract offered by the firm for fixed compensation. The subjective evaluation contract is an increasing incentive scheme since the worker receives a high compensation when the firm reports an acceptable performance and a low compensation otherwise. For an incentive scheme like this, the participation effect is favorable to the firm: a worker who displays overestimation overvalues the contract as this offers higher compensation in states the worker overestimates and lower compensation in states the worker underestimates. The in-

centive effect is the impact of overestimation on the worker's willingness to exert high effort for fixed compensation. The incentive effect is favorable (unfavorable) to the firm when it makes high effort more (less) attractive than low effort. Finally, the truth telling effect of overestimation is the impact of overestimation on the worker's willingness to truthfully report his performance evaluation for fixed compensation. Interestingly, the truth telling effect of overestimation is neither favorable nor unfavorable to the firm. Hence, overestimation makes the firm better off when the participation and incentive effects are both favorable to the firm. When the participation effect is favorable and the incentive effect is unfavorable, the firm can be either better off or worse depending on which effect dominates. In either case, overestimation never leads to a Pareto improvement.

Third, the optimal contract for a worker who displays overprecision can be quite different to the optimal contract for a rational worker. When the overprecision bias is large enough, the firm wagers on the compensation offered to the worker in each state, that is, in each possible realization of the performance evaluations. The firm promises higher compensation in states where the performance evaluations coincide and lower compensation when the principal deems acceptable a performance deemed unacceptable by the agent. This simultaneously raises the worker's perceived expected compensation and lowers the firm's expected wage cost. In this new type of contract, the worker's compensation depends on both performance evaluation reports, while the firm's wage cost only depends on the worker's report. Hence, when the overprecision bias is large enough, the firm offers a contract that uses the worker's performance evaluation as an input to set compensation. This is a novel result that might explain why boards and compensation committees often use a CEO's self-appraisal of the firm's performance—in the form of a written letter—as an input to set the CEO's compensation (Mone 2009).²

²For example, the Board Manual of the Grand River Hospital in Ontario, Canada, states: "Through discussions held without the CEO, [executive committee] members determine a recommendation for year-end performance based compensation taking into account the CEO's self-appraisal, the most recent CEO's report of the hospital's performance against the operating plan and budget and the results of the 360° survey."

Fourth, the impact of overprecision on social welfare depends on the intensity of the worker's bias. When the overprecision bias is moderate, there is a Pareto improvement since overprecision lowers the firm's expected wage cost and raises the worker's expected compensation. In contrast, when the overprecision bias is significant, there is exploitation since the firm is better off and the worker is worse off. The intuition behind this result is as follows. Overprecision, like overestimation, leads to participation, incentive, and truth telling effects. When the overprecision bias is large enough, all three effects are favorable to the firm. However, this does not necessarily lead to an exploitative contract. A worker who displays overprecision, unlike one who displays overestimation, expects to be in agreement with the firm more often than he should, and expects conflict to happen less often than he should. As a consequence, overprecision lowers the deadweight loss associated with subjective evaluation contracts. When the worker's overprecision bias is moderate, so is the firm's motive to wager of the worker's bias, and the contract features a lower deadweight loss and a higher expected compensation than those for a rational worker. However, when the worker's overprecision bias is significant, so is the firm's motive to wager of the worker's bias, and the contract features a lower deadweight loss as well as a lower expected compensation than those for a rational worker. The Pareto improvement result is consistent with the theory of the second-best (Lipsey and Lancaster 1956). According to this theory introducing a new distortion—worker overprecision—in an environment where other distortions are already present—hidden action and information—can increase welfare.

Besides these four key findings, the paper derives two additional results. First, the firm's incentives to select high effort, as opposed to low effort, are weakly higher when the worker displays overprecision. Second, underconfidence has different implications for the design of subjective evaluation contracts and for welfare than overconfidence.

Our study contributes to the literature on subjective evaluation, an intense subject of study in labor economics. Seminal contributions like MacLeod and Malcolmson (1989), Baker et al. (1994), Levin (2003), and MacLeod (2003), have sparked

research interests that are still ongoing today (among others: Fuchs 2007, Chan and Zheng 2011, Zábajník 2014, Fuchs 2015, and MacLeod and Tan 2017). Within this literature the closest study to ours is MacLeod (2003). The main novelty is that our study shows that worker overprecision can lead to a different type of subjective evaluation contract that uses the worker’s performance evaluation as an input to set compensation. In addition, it shows that worker overprecision can lead to a Pareto improvement by lowering the deadweight loss associated with subjective evaluation contracts.

Our study also contributes to the growing literature on the impact of overconfidence on key contractual aspects of the employment relationship (among others: Bénabou and Tirole 2003, Fang and Moscarini 2005, Van den Steen 2005, Gervais and Goldstein 2007, Goel and Thakor 2008, Santos-Pinto 2008, 2010, de la Rosa 2011, and Gervais et al. 2011). Finally, our study contributes to the literature on exploitative contracting. Notable contributions are Della Vigna and Malmendier (2004), Gabaix and Laibson (2006), Eliaz and Spiegler (2008), Heidhues and Kőszegi (2010), and Heidhues et al. (2016, 2017). Our study provides conditions under which the new contracts we derive do not necessarily feature an “exploitative nature,” in the sense of making the firm better off and the worker worse off (compared to the case of a rational agent). When these conditions aren’t met, however, the firm does exploit the worker’s overconfidence.

The remainder of paper is organized as follows. Section 2 sets-up the model, defines biases in beliefs, and formalizes the firm’s problem. Section 3 derives the optimal contracts and discusses the impact of overconfidence on social welfare. Section 4 considers the impact of overconfidence on the firm’s effort selection problem. Section 5 shows our results hold regardless of the agent’s outside option being either large or small. Section 6 discusses underconfidence. Section 7 concludes the paper. The Appendix contains the proofs and derivations of all results, except those in Sections 5 and 6 which are in the Online Appendix.

2 The Model

This section sets-up the model, defines biases in beliefs, and formalizes the firm’s problem.

2.1 Set-up

A risk neutral principal (she) offers a one period contract to a risk neutral agent (he). If the agent accepts the contract, he undertakes a project by choosing between low and high effort $\lambda \in \{\lambda^L, \lambda^H\}$, where $0 \leq \lambda^L < \lambda^H \leq 1$. The performance of the project is *good* (G) if output $Y > 0$ is realized and *bad* (B) if Y is not realized, in which case the project’s output is equal to zero. When the agent exerts effort λ , output Y is realized with probability λ . The agent’s ex-post utility when he receives compensation c for his work and exerts effort λ is $U(c, \lambda) = c - V(\lambda)$, where $V(\lambda)$ is the cost of the effort with $0 \leq V(\lambda^L) < V(\lambda^H)$. The agent is protected by limited liability, that is, $c \geq 0$ and has access to an outside option granting him $\bar{u} \geq 0$.

Following MacLeod (2003), the agent’s effort and the project’s performance are neither observable nor contractible. The performance of the project generates separate private (and hence subjective) signals for the principal and the agent. The principal privately observes a measure of performance or signal T and the agent privately observes a measure of performance or signal S . Signals T and S have realizations $t \in \{a, u\}$ and $s \in \{a, u\}$, respectively. Realization a (u) corresponds to an “acceptable” (“unacceptable”) performance.³ In particular, we let $\gamma_t^G = \Pr\{T = t|G\}$ and $\gamma_t^B = \Pr\{T = t|B\}$ denote the probability that signal T results in $t \in \{a, u\}$ when the outcome of the project is good or bad, respectively.

Assumption 1. *Signal T is positively correlated with the outcome of the project:*

$$\gamma_a^G > \gamma_a^B \quad \text{and} \quad \gamma_u^G < \gamma_u^B$$

³The model allows for two different interpretations. The acceptable or unacceptable performance may be either the agent’s or the project’s overall.

This assumption implies that the principal's signal is informative about the performance of the project. The realization of signal S is described as a function of T . Let $P_{ts} = \Pr\{S = s|T = t\}$. The probability of $(T, S) = (t, s)$ occurring in states G and B is $\gamma_{ts}^G = \Pr\{T = t, S = s|G\} = P_{ts}\gamma_t^G$ and $\gamma_{ts}^B = \Pr\{T = t, S = s|B\} = P_{ts}\gamma_t^B$, respectively. The probability of $(T, S) = (t, s)$ occurring given effort levels λ^H and λ^L is:

$$\begin{aligned}\gamma_{ts}^H &= \Pr\{T = t, S = s|\lambda^H\} = \lambda^H\gamma_{ts}^G + (1 - \lambda^H)\gamma_{ts}^B \\ \gamma_{ts}^L &= \Pr\{T = t, S = s|\lambda^L\} = \lambda^L\gamma_{ts}^G + (1 - \lambda^L)\gamma_{ts}^B,\end{aligned}$$

respectively.

Assumption 2. For any λ^j , signals are positively correlated in the following sense:

$$P_{aa}P_{uu} - P_{au}P_{ua} > 0.$$

This assumption on the signal structure follows MacLeod (2003) and implies that the principal's signal is more informative than the agent's signal in the sense defined by Blackwell (1951, 1953). Assumption 2 also has implications on the conditional distributions of signals.

Lemma 1. Given the positive correlation of signals the following are true:

- (i) $\gamma_{ts}^j = P_{ts} \Pr [T = t|\lambda^j] \equiv P_{ts}\Gamma_t^j$ for $j = H, L$,
- (ii) $\gamma_{aa}^j\gamma_{uu}^j - \gamma_{au}^j\gamma_{ua}^j > 0$ for $j = H, L$,
- (iii) $P_{aa} > P_{ua}$ and $P_{uu} > P_{au}$.
- (iv) $\Delta\Gamma_a + \Delta\Gamma_u = 0$, where $\Delta\Gamma_t = \Gamma_t^H - \Gamma_t^L$.

2.2 Biases in Beliefs

Overestimation is a well documented bias in judgement and has been observed in the workplace. CEOs of large U.S. companies generally overestimate their ability to raise the company's stock price and consequently they hold their stock options for too long (Malmendier and Tate, 2005, 2008, Malmendier et al., 2011). Truck drivers systematically and persistently overestimate the number of miles they drive each week (Hoffman and Burks, 2019). Most people tend to display overestimation but some display underestimation.

To model over and underestimation, we assume the agent and the principal agree to disagree on the probability of output Y being realized for any given effort exerted. Moreover, we define overestimation as follows.

Definition 1. *The agent displays overestimation if he believes that his probability of attaining a good project outcome is higher than it actually is for any given level of effort λ , that is, $\tilde{\lambda}^H > \lambda^H$ and $\tilde{\lambda}^L > \lambda^L$, with $1 > \tilde{\lambda}^H > \tilde{\lambda}^L > 0$.*

Similarly, we define underestimation as follows.

Definition 2. *The agent displays underestimation if he believes his probability of attaining a good project outcome is lower than it actually is for any given level of effort λ , that is, $\tilde{\lambda}^H < \lambda^H$ and $\tilde{\lambda}^L < \lambda^L$, with $1 > \tilde{\lambda}^H > \tilde{\lambda}^L > 0$.*

As described in its definition, the nature of overestimation is for an agent to believe, mistakenly, that the probability that his performance is acceptable is higher than it actually is. In fact, denoting the biased probabilistic beliefs of the agent with $\tilde{\Pr}\{\cdot\}$ and $\tilde{\Pr}[T = t|\lambda^j] = \tilde{\Gamma}_t^j = \tilde{\lambda}^j \gamma_t^G + (1 - \tilde{\lambda}^j) \gamma_t^B$, from basic probability theory we get:

$$\begin{aligned} \tilde{\Pr}\{S = a|\lambda^j\} &= \Pr\{S = a|T = a\} \tilde{\Pr}\{T = a|\lambda^j\} + \Pr\{S = a|T = u\} \tilde{\Pr}\{T = u|\lambda^j\} \\ &= P_{aa} \tilde{\Gamma}_a^j + P_{ua} \tilde{\Gamma}_u^j > P_{aa} \Gamma_a^j + P_{ua} \Gamma_u^j = \Pr\{S = a|\lambda^j\}. \end{aligned}$$

Furthermore, since the signals are positively correlated, the nature of overestimation is for the agent to believe, mistakenly, that the probability his performance is deemed acceptable by the principal is higher than it actually is. Finally, the nature of overestimation is for an agent to believe, mistakenly, that states where the principal deems his performance acceptable $((a, a)$ and $(a, u))$ have a higher probability than they actually have ($\tilde{\gamma}_{aa}^j > \gamma_{aa}^j$ and $\tilde{\gamma}_{au}^H > \gamma_{au}^j$), and that states where the principal deems his performance unacceptable $((u, a)$ and $(u, u))$ have a lower probability than they actually have ($\tilde{\gamma}_{ua}^j < \gamma_{ua}^j$ and $\tilde{\gamma}_{uu}^j < \gamma_{uu}^j$).

Overprecision is also a well documented judgement bias. Experimental evidence shows that most people, even experts, overestimate the accuracy of their private information, estimates, and forecasts (Oskamp 1965, Fischhoff et al. 1977, Christensen-Szalanski and Bushyhead 1981, Lichtenstein et al. 1982, Heath and Tversky 1991, Wallsten et al. 1993, Barberis and Thaler 2003, Hoffrage 2016). Top U.S. chief financial officers (CFOs) estimates of 80 percent confidence intervals for the expected annual S&P 500 returns only contain the actual realized returns 33 percent of the time. In addition, CFO overconfidence is correlated with own-firm project overconfidence and increased corporate investment (Ben-David et al. 2013). While the majority of individuals display overprecision, a minority displays underprecision.

To model over and underprecision, we assume the agent and the principal agree to disagree on the conditional distribution of S . In particular, we assume that, given that the principal has observed $T = t$, the agent's perceived probability of observing $S = s$ is altered by some amount b_t . More precisely, regardless of the effort exerted, we have $\tilde{P}_{aa} = P_{aa} + b_a$, $\tilde{P}_{au} = P_{au} - b_a$, $\tilde{P}_{ua} = P_{ua} + b_u$, and $\tilde{P}_{uu} = P_{uu} - b_u$, with $b_a \in [-P_{aa}, P_{au}]$ and $b_u \in [-P_{ua}, P_{uu}]$.⁴ Based on this specification, we define overprecision as follows.

Definition 3. *The agent displays overprecision if he believes his SPE signal is more informative about the outcome of the project than it actually is, that is $\tilde{\Pr}\{S = a|G\} > \Pr\{S = a|G\}$ and $\tilde{\Pr}\{S = u|B\} > \Pr\{S = u|B\}$. Equivalently, the agent's*

⁴The posed boundaries are needed for all $\tilde{P}_{ts} \in [0, 1]$ to hold.

beliefs satisfy:

$$b_a > 0 \quad \text{and} \quad -\frac{\gamma_a^G}{\gamma_u^G} b_a < b_u < -\frac{\gamma_a^B}{\gamma_u^B} b_a \quad (1)$$

Similarly, we define an underprecision as follows.

Definition 4. *The agent displays underprecision if he believes his SPE signal is less informative about the outcome of the project than it actually is, that is $\tilde{\Pr}\{S = a|G\} < \Pr\{S = a|G\}$ and $\tilde{\Pr}\{S = u|B\} < \Pr\{S = u|B\}$. Equivalently, the agent's beliefs satisfy:*

$$b_a < 0 \quad \text{and} \quad -\frac{\gamma_a^G}{\gamma_u^G} b_a < b_u < -\frac{\gamma_a^B}{\gamma_u^B} b_a \quad (2)$$

The nature of overprecision is for an agent to believe, mistakenly, that states where the performance evaluations coincide ((a, a) and (u, u)) have a higher probability than they actually have ($\tilde{\gamma}_{aa}^j > \gamma_{aa}^j$ and $\tilde{\gamma}_{uu}^H > \gamma_{uu}^j$), and that states where the performance evaluations differ ((a, u) and (u, a)) have a lower probability than they actually have ($\tilde{\gamma}_{au}^j < \gamma_{au}^j$ and $\tilde{\gamma}_{ua}^j < \gamma_{ua}^j$). An important aspect that needs attention is how over and underprecision affects the agent's beliefs about the correlation between the two signals, that is, the direction and extent of the agent's perceived correlation between signals.

Lemma 2. *Given Assumption 2, when an agent who displays either over or underprecision has a bias that satisfies:*

$$b_u - b_a \leq P_{aa} - P_{ua}, \quad (3)$$

he believes that signals are positively correlated, i.e., $\tilde{P}_{aa}\tilde{P}_{uu} - \tilde{P}_{au}\tilde{P}_{ua} > 0$.

It follows from (1) that an agent who displays overprecision always believes signals are positively correlated. However, it follows from (2) that an agent who displays underprecision might believe signals are either positively or negatively correlated.

Under perceived positive correlation, both parties agree on the fact that the principal is the expert, that is, they agree that the principal has the most informative signal. This assumption is the most natural one to make and allows us to directly compare our results to subjective evaluation settings where the principal is assumed to be the expert and the agent is rational.

The principal is assumed to be perfectly informed about the agent's biased beliefs. This assumption should be viewed as a reasonable simplification. The psychological evidence that individuals are prone to be overconfident is widespread and publicly available. If the bias is systematic, the principal could at least be expected to make a good guess about the mistaken beliefs of a particular agent by assuming the agent is overconfident.

2.3 The Effort Implementation Problem

The timing of the interaction is as follows: (1) the principal offers a contract $\{w_{i\hat{s}}, c_{i\hat{s}}\}$ which specifies the principal's wage cost $w_{i\hat{s}}$ and the agent's compensation $c_{i\hat{s}}$ for any given performance evaluation reports $\hat{t} \in \{a, u\}$ and $\hat{s} \in \{a, u\}$, (2) the agent either accepts the contract or rejects it, (3) the agent privately selects effort $\lambda \in \{\lambda^L, \lambda^H\}$, (4) the project's performance is realized and generates signal realizations $t \in \{a, u\}$ and $s \in \{a, u\}$, (5) the parties privately observe their signal realizations and make their performance evaluation reports $\hat{t} \in \{a, u\}$ and $\hat{s} \in \{a, u\}$ simultaneously and independently, and (6) the parties' payoffs are realized according to the contract.

The principal's objective is to incentivize the agent to exert the level of effort that maximizes her expected profits. Following Grossman and Hart (1983), this problem can be divided into two steps. First, deriving the minimum expected wage cost of implementing each effort level – the *effort implementation problem*. Second, given the minimum expected wage cost of each effort level, select the effort level that maximizes the principal's expected profit – the *effort selection problem*.

The analysis focuses on the optimal contract that incentivizes the agent to exert

high effort since this is the most interesting case.⁵ Nevertheless, we also derive the optimal contract that incentivizes low effort (see Lemmas 16 and 22). This allows us to describe the impact of overconfidence on the principal's effort selection problem. By the revelation principle, it is sufficient to consider only contracts where both parties have an incentive to reveal their private information in equilibrium. Hence, the principal faces the following constrained minimization problem:

$$\begin{aligned}
\min_{\{w_{ts}, c_{ts}\}_{t,s \in \{u,a\}}} & w_{aa}\gamma_{aa}^H + w_{au}\gamma_{au}^H + w_{ua}\gamma_{ua}^H + w_{uu}\gamma_{uu}^H & (4) \\
\text{s.t.} & \sum_{ts} c_{ts}\tilde{\gamma}_{ts}^H - V(\lambda^H) \geq \bar{u} & (PC) \\
& \sum_{ts} c_{ts}\tilde{\gamma}_{ts}^H - V(\lambda^H) \geq \sum_{ts} c_{ts}\tilde{\gamma}_{ts}^L - V(\lambda^L) & (IC) \\
& w_{aa}\gamma_{aa}^H + w_{au}\gamma_{au}^H \leq w_{ua}\gamma_{aa}^H + w_{uu}\gamma_{au}^H & (TR_P^a) \\
& w_{ua}\gamma_{ua}^H + w_{uu}\gamma_{uu}^H \leq w_{aa}\gamma_{ua}^H + w_{au}\gamma_{uu}^H & (TR_P^u) \\
& c_{aa}\tilde{\gamma}_{aa}^H + c_{ua}\tilde{\gamma}_{ua}^H \geq c_{au}\tilde{\gamma}_{aa}^H + c_{uu}\tilde{\gamma}_{ua}^H & (TR_A^a) \\
& c_{au}\tilde{\gamma}_{au}^H + c_{uu}\tilde{\gamma}_{uu}^H \geq c_{aa}\tilde{\gamma}_{au}^H + c_{ua}\tilde{\gamma}_{uu}^H & (TR_A^u) \\
& w_{ts} \geq c_{ts} \geq 0 \quad \forall t, s \in \{a, u\}. & (LL_{ts})
\end{aligned}$$

The objective function represents the principal's wage cost of implementing high effort. The first two constraints are the classical participation and incentive constraints. They ensure the agent is willing to accept the contract, (PC) , and to exert high effort instead of low effort, (IC) . Constraints (TR_P^t) are the principal's truthful reporting constraints and ensure that she is willing to report t truthfully when she observes $T = t$. Similarly, (TR_A^s) are the agent's truthful reporting constraints and ensure that he is willing to report s truthfully when he observes $S = s$. Notice that this implies an important distinction. The realizations of signals, t and s , are not necessarily equal to the performance evaluation reported to the other party. Here-

⁵One can always find a value for Y such that the principal prefers to implement high effort instead of low effort.

after we use the word “signal” to indicate the actual realization of T and S and “performance evaluation report” to indicate the reported value of his/her own signal by one party to the other. The (TR) constraints ensure that the two coincide in equilibrium.⁶ Last, is a set of constraints (LL_{ts}) that ensure feasibility ($w_{ts} \geq c_{ts}$) and limited liability on the side of the agent ($c_{ts} \geq 0$).

Equilibrium concept. Note that problem (4) solves the model under the assumption of *good-faith*, introduced by MacLeod and Tan (2017). A contract solving (4) is incentive compatible with respect to one-stage deviations. In other words, the problem above ensures the agent neither intends to exert low effort when he truthfully reports his signal nor to misreport his signal when he exerts high effort. However, the problem above does not incentivize the agent to report his signal truthfully when he exerts low effort. In other words, problem (4) does not ensure the agent cannot gain with a two-stage deviation whereby he chooses low effort and misreports his signal. It is assumed that the agent will not do so in good-faith. While this is a weaker requirement compared to Perfect Bayesian Equilibrium (also called *guile-free* contracts in MacLeod and Tan 2017) it simplifies the computations substantially while not affecting the results. The good-faith assumption is consistent with empirical evidence on how individuals respond to immediate incentives but often fail to contemplate more complex deviations (DellaVigna and Malmendier 2006) and with experimental evidence that shows subjects have difficulty making state-contingent reasoning about hypothetical scenarios (Charness and Levin 2009, Esponda and Vespa 2014, Ngangoue and Weizsacker 2015).⁷

The optimal contracts we derive in Section 3 assume the agent’s outside option \bar{u} is small. This ensures the (PC) is satisfied and allows us to ignore it from the analysis. However, we show in the Appendix that the optimal contracts indeed satisfy the (PC) . Furthermore, Section 5 shows that our main results also hold when the

⁶Technically we could define \hat{t} and \hat{s} as the performance evaluation reports. Since the (TR) ensures that $\hat{t} = t$ and $\hat{s} = s$ we omit this notation in order not to complicate the exposition.

⁷We discuss this in the Online Appendix, where we also show that the (TR_P^t) constraints do incentivize the principal to always report truthfully, regardless of the effort exerted by the agent.

agent’s outside option is large. Finally, in order to solve problem (4), we present a set of Lemmas in the Appendix that select the binding constraints and reduce the choice variables of the problem from eight to only two: c_{aa} and c_{au} .

As is well known, a subjective evaluation contract has to ensure the principal has an incentive to report an acceptable performance evaluation that results in higher compensation for the agent. For this to happen the principal must be prepared to suffer a deadweight loss. The deadweight loss captures the notion of conflict in a relationship, which might happen when the parties disagree on their performance evaluations.⁸ This is a standard feature of subjective evaluation contracts (MacLeod 2003) and is often also referred to as “money burning.” Our set-up allows the agent to impose, without cost, a deadweight loss upon the principal. We define $\Delta V = V(\lambda^H) - V(\lambda^L)$ and the expected deadweight loss from using a subjective evaluation contract that implements high effort as $\sum_{ts} (w_{ts} - c_{ts}) \gamma_{ts}^H$.

Finally, to study the impact of overconfidence on the agent’s welfare we take the ex-ante point of view of an outside observer, who knows the actual probability of output Y being realized for any given effort exerted (in the case of overestimation) and the actual distribution of the agent’s private performance evaluation (in the case of overprecision).⁹

⁸For instance, the worker may decide to “punish” the firm by performing badly or sabotaging future projects. Mas (2006, 2008) provides direct evidence of employees imposing direct costs upon employers through private actions. These costs include a decrease in future effort (Mas, 2006) or a direct reduction in the quality of the output (Mas, 2008). However, there are also examples of employers imposing direct costs upon employees. In the sports and entertainment businesses, athletes and performers (e.g., actors and musicians) are often subject to fines, which are either re-invested in the club or often given to charities, or are not called up for a particular game or show.

⁹The agent’s welfare could also be assessed as he perceives it ex ante, that is, using the agent’s perception of his performance evaluation signal. However, the agent will not experience this welfare on average ex post.

3 Optimal Contracts and Social Welfare

Our first result describes the optimal contract for a rational agent, which we refer to as the *Baseline Performance Evaluation* (BPE) contract.

Proposition 1. *If the agent is rational and his outside option satisfies $\bar{u} \leq \bar{u}_1$, then he is offered a BPE contract given by:*

$$\begin{aligned} w_{aa}^* &= c_{aa}^* & w_{au}^* &= c_{aa}^* & w_{uu}^* &= 0 & w_{ua}^* &= \frac{c_{aa}^*}{P_{aa}} \\ c_{aa}^* &= \frac{\Delta V}{\Delta \Gamma_a} & c_{au}^* &= c_{aa}^* & c_{uu}^* &= 0 & c_{ua}^* &= 0. \end{aligned}$$

The BPE contract features:

- (i) a compensation that depends only on the principal's performance evaluation report;
- (ii) a wage cost that depends on both parties' performance evaluation reports;
- (iii) a positive compensation when the principal reports an acceptable performance and no compensation otherwise;
- (iv) a deadweight loss when the principal reports an unacceptable performance and the agent reports an acceptable performance;¹⁰
- (v) the highest wage cost when the principal reports an unacceptable performance and the agent reports an acceptable performance.

¹⁰The deadweight loss takes place following state (u, a) due to three reasons. First, the principal wants to punish the agent in the lowest state, that is, when the principal's performance evaluation is unacceptable, $t = u$. This is the state where a deviation to low effort is more likely to have occurred. Second, since the signals are positively correlated, a deadweight loss following state (u, u) would be suboptimal, since it would take place more often than following state (u, a) . Finally, if the deadweight loss were not in place, the principal (agent) would have the dominant strategy of reporting the performance as unacceptable (acceptable). Hence, the deadweight loss happens after state (u, a) in order to take both parties away from their dominant strategy.

The above replicates the standard result of the literature with rational agents (MacLeod 2003) and it provides us with a basis of comparison for the contracts derived hereafter. The key features of the BPE contract are as follows. First, the agent's compensation only depends on the principal's performance evaluation. Second, the principal's wage cost depends on both performance evaluations. Third, the agent's compensation is higher when the principal reports an acceptable performance than when she reports an unacceptable performance.

The next result describes the optimal contract for an agent who displays overestimation.

Proposition 2. *If the agent is overconfident in the sense of overestimation and his outside option satisfies $\bar{u} \leq \bar{u}_2$, then he is offered a contract given by:*

$$\begin{aligned} w_{aa}^\diamond &= c_{aa}^\diamond & w_{au}^\diamond &= c_{aa}^\diamond & w_{uu}^\diamond &= 0 & w_{ua}^\diamond &= \frac{c_{aa}^\diamond}{P_{aa}} \\ c_{aa}^\diamond &= \frac{\Delta V}{\Delta \tilde{\Gamma}_a} & c_{au}^\diamond &= c_{aa}^\diamond & c_{uu}^\diamond &= 0 & c_{ua}^\diamond &= 0. \end{aligned}$$

The contract in Proposition 2 shows that the principal adapts the compensation and the wage cost in response to the agent's overestimation. This depends critically on whether overestimation makes it more or less attractive for the agent to exert high effort for fixed compensation. We discuss each case separately below.

When the agent's overestimation of the project's success probability is greater for high effort than for low, i.e., $\Delta \tilde{\lambda} = \tilde{\lambda}^H - \tilde{\lambda}^L > \Delta \lambda = \lambda^H - \lambda^L$, overestimation has a favorable *incentive effect*. This means that overestimation relaxes the agent's incentive constraint for fixed compensation. The principal reacts to this type of overestimation by lowering compensation in states where she deems the agent's performance acceptable while keeping compensation unchanged in states where she deems the agent's performance unacceptable. This is accomplished without violating the agent's truthful reporting constraints by lowering c_{aa} and c_{au} by the same amount while leaving c_{ua} and c_{uu} unchanged.¹¹ This, in turn, together with the principal's

¹¹Note that $\Delta \tilde{\lambda} > \Delta \lambda$ implies $\Delta \tilde{\Gamma}_a > \Delta \Gamma_a$ since $\Delta \tilde{\Gamma}_a = \Delta \tilde{\lambda} \gamma_a^G + (1 - \Delta \tilde{\lambda}) \gamma_a^B$, $\Delta \Gamma_a = \Delta \lambda \gamma_a^G +$

truthful reporting and feasibility constraints, implies that the principal can lower w_{aa} , w_{au} , and w_{ua} while leaving w_{uu} unchanged. Hence, this type of overestimation makes the principal better off since it lowers her expected wage cost. Taking the perspective of an outside observer, this type of overestimation makes the agent worse off since it lowers his actual expected compensation.

In contrast, when the agent's overestimation of the project's success probability is smaller for high effort than for low, i.e., $\Delta\tilde{\lambda} < \Delta\lambda$, overestimation has an unfavorable incentive effect. This means that overestimation tightens the agent's incentive constraint for fixed compensation. The principal responds to this type of overestimation by raising compensation in states where she deems the agent's performance acceptable while keeping compensation unchanged in states where she deems the agent's performance unacceptable. This is attained without violating the agent's truthful reporting constraints by raising c_{aa} and c_{au} by the same amount while leaving c_{ua} and c_{uu} unchanged. This, in turn, together with the principal's truthful reporting and feasibility constraints, implies that the principal must raise w_{aa} , w_{au} , and w_{ua} while leaving w_{uu} unchanged. Hence, this type of overestimation makes the principal worse off since it raises her expected wage cost. Taking the perspective of an outside observer, this type of overestimation makes the agent better off since it raises his actual expected compensation.

Overestimation also has implications for the deadweight loss of subjective performance evaluation. As mentioned before, the deadweight loss ensures the principal truthfully reports an acceptable performance evaluation that results in higher compensation for the agent. In addition, the deadweight loss takes place in state (u, a) , that is, the state where the principal deems unacceptable a performance deemed acceptable by the agent, and is equal to $(w_{ua} - c_{ua})\gamma_{ua}^H$. We know from Propositions 1 and 2 that the agent's compensation in state (u, a) is set equal to zero in both contracts, i.e., $c_{ua}^* = c_{ua}^\diamond = 0$. Therefore, the deadweight losses of the two contracts are $w_{ua}^*\gamma_{ua}^H$ and $w_{ua}^\diamond\gamma_{ua}^H$, respectively. As a consequence, the contract with the lowest $(1 - \Delta\lambda)\gamma_a^B$, and $\gamma_a^G > \gamma_a^B$.

deadweight loss boils down to the one with the lowest wage cost in state (u, a) . When overestimation has a favorable incentive effect, it lowers the deadweight loss of subjective performance evaluation since $\Delta\tilde{\lambda} > \Delta\lambda$ implies $\Delta\tilde{\Gamma}_a > \Delta\Gamma_a$, which, in turn, implies $w_{ua}^* > w_{ua}^\diamond$. In contrast, when overestimation has an unfavorable incentive effect, it raises the deadweight loss of subjective performance evaluation since $\Delta\tilde{\lambda} < \Delta\lambda$ implies $\Delta\tilde{\Gamma}_a < \Delta\Gamma_a$, which, in turn, implies $w_{ua}^* < w_{ua}^\diamond$.

Proposition 2 contributes to the literature on impact of worker overestimation on the social welfare of employment relationships. The most closely related studies are Santos-Pinto (2008) and de la Rosa (2011) who consider the impact of worker overestimation when the firms use objective evaluation contracts. Santos-Pinto (2008) shows that the firm can be better off with a worker who displays overestimation by paying him less than what a rational worker would demand. This depends critically on the *participation* and *incentive effects* of overestimation. When both effects are favorable to the principal, the agent's overestimation makes the principal better off. De la Rosa (2011) finds that when the agent's overestimation is significant there is exploitation but when overestimation is only slight there can be either a Pareto worsening or exploitation.

Proposition 2 extends Santos-Pinto (2008) findings to subjective evaluation contracts. The main difference between objective and subjective evaluation contracts is the fact that in a subjective evaluation contract, the agent and the principal must truthfully reveal their private subjective evaluations. The agent's overestimation can potentially affect the agent's truthful reporting constraints. However, it turns out that overestimation has no impact on the agent's truth telling constraints for fixed compensation. As we will see, this is no longer the case with overprecision.

The contract in Proposition 2 is designed for an agent with a small outside option. This is the reason why only the incentive effect plays a role. When the agent's outside option is large, the participation effect also plays a role. In Section 5 we discuss the optimal contract for an agent with a large outside option. In this case, the participation effect is always favorable to the principal, that is, overestimation always

relaxes the agent's participation constraint for fixed compensation. Hence, when the agent's outside option is large and overestimation makes high effort more attractive to the agent for fixed compensation, both effects are favorable to the principal and she is better off. Similarly, to de la Rosa (2011), we find that overestimation never leads to a Pareto improvement. Overall, our findings on the impact of overestimation on subjective performance evaluation contracts are in line with Santos-Pinto (2008) and de la Rosa (2011).

Our next result describes the optimal contract for an agent who displays overprecision. It shows that if the overprecision bias b_a is large, the principal offers a new type of subjective evaluation contract which we refer to as the *Agent Performance Evaluation* (APE) contract.

Proposition 3. *If the agent is overconfident in the sense of overprecision, his outside option satisfies $\bar{u} \leq \bar{u}_3$, and his beliefs satisfy*

$$b_a \geq P_{au} \frac{\Gamma_u^H \Gamma_a^H (P_{aa} - P_{ua}) + (P_{uu} - b_u) (P_{aa} \Gamma_a^H + P_{ua} \Gamma_u^H) \Gamma_a^H}{\Gamma_u^H \Gamma_a^H (P_{aa} - P_{ua}) + (P_{uu} - b_u) (P_{aa} \Gamma_a^H + P_{ua} \Gamma_u^H)}, \quad (5)$$

then he is offered an APE contract given by:

$$\begin{array}{llll} w_{aa}^\dagger = c_{aa}^\dagger & w_{au}^\dagger = c_{au}^\dagger & w_{uu}^\dagger = c_{au}^\dagger & w_{ua}^\dagger = c_{aa}^\dagger \\ c_{aa}^\dagger = c_{au}^\dagger \left(1 + \frac{\tilde{\gamma}_{uu}^H}{\tilde{\gamma}_{au}^H}\right) & c_{au}^\dagger = \frac{\Delta V}{\Delta \Gamma_a} \frac{\tilde{P}_{au} \Gamma_a^H}{\tilde{P}_{au} \Gamma_a^H + \tilde{P}_{uu} (\tilde{P}_{aa} - \Gamma_a^H)} & c_{uu}^\dagger = c_{au}^\dagger & c_{ua}^\dagger = 0. \end{array}$$

The APE contract features:

- (i) a compensation that depends on both parties' performance evaluation reports;
- (ii) a wage cost that depends only on the agent's performance evaluation report;
- (iii) a high wage when the agent reports an acceptable performance and a low wage otherwise.

(iv) a deadweight loss when the principal reports an unacceptable performance and the agent reports an acceptable performance which is smaller than the deadweight loss in a BPE contract;

(v) the highest compensation when both parties report an acceptable performance;

If the agent is overconfident in the sense of overprecision, his outside option satisfies $\bar{u} \leq \bar{u}_3$, and his beliefs violate (5), then he is assigned a BPE contract.

Proposition 3 shows that if the agent’s overprecision bias b_a is large enough, the principal is willing to offer a contract tailored to the agent’s beliefs in order to lower her expected wage cost. The APE contract is tied mostly to the agent’s opinion, that is, the principal is “giving in” to the agent at the contracting stage. This ensures that the agent is happy to sign the contract, as his opinion and assessment are going to almost entirely drive the economic interaction. More specifically, the APE contract departs from the BPE contract in Proposition 1 in three key ways.

First, the agent’s compensation in the APE contract depends on both performance evaluation reports whereas in the BPE contract it only depends on the principal’s report. This is a surprising result: when the agent’s overprecision bias b_a is large enough, the principal uses the agent’s performance evaluation report (or self-appraisal) as an input to set compensation. This stands in contrast to the general recommendation in the management literature against the use of self-appraisals to set compensation (Campbell and Lee 1988, Milkovich et al. 2011, Bratton and Gold 2012).¹² The intuition behind this result is as follows. When the agent is rational, the principal’s performance evaluation is a sufficient statistic about the agent’s effort and it is therefore the only information needed for the principal to set the agent’s

¹²The main reason the management literature does not recommend the use of self-appraisals as an evaluation tool is due to the leniency effect associated with self-evaluations (Farh and Dobbins 1989, Harris and Schaubroeck 1988) which might lead to conflict between supervisors and workers. However, this criticism does not apply to our setting since the agent’s truth-telling constraints prevent him from misreporting his performance evaluation.

compensation in the BPE. This result follows from Holmström’s (1979) informativeness principle.^{13,14} In contrast, when the agent’s overprecision bias b_a is large enough, there is a trade-off between the information motive (only use T since it is a sufficient statistic about the agent’s effort) and the wagering motive (only use S since this maximizes the degree to which the agent overestimates his expected compensation). As such, the principal must tie the agent’s compensation not only to the principal’s performance evaluation T but also to the agent’s performance evaluation S even though S carries no additional informational value. By cleverly manipulating the wage cost and the compensation in the different states according to the agent’s bias, the principal is able to simultaneously lower her expected wage cost and raise the agent’s perceived expected compensation. To do this, the principal promises higher compensation in states where the performance evaluations coincide, states whose likelihoods the agent overestimates, and lower compensation when the principal deems acceptable a performance deemed unacceptable by the agent, a state whose likelihood the agent underestimates.¹⁵

Second, the principal’s wage cost in the APE contract only depends on the agent’s

¹³According to Holmström (1979), T is a sufficient statistic for the pair (T, S) about the agent’s effort λ if $f(t, s; \lambda) = g(t, s)h(t, \lambda)$ for almost every (t, s) . This is true in our set-up since $\gamma_{ts}^j = P_{ts}[\lambda^j \gamma_G^t + (1 - \lambda^j) \gamma_B^t]$. In other words, T carries all the relevant information about the agent’s effort λ , and S adds nothing to the power of inference about λ (even though S is positively correlated with T and the project). Hence, if Y , T , and S were all observable and verifiable (they were objective performance measures), then only Y and T would be used in a contract in order to incentivize the agent. In our model Y , T , and S are neither observable nor verifiable, however, truth telling by both parties, implies that the principal’s performance evaluation is a sufficient statistic for both performance evaluations about the agent’s effort λ . Hence, the agent’s performance evaluation does not add to the power of inference about λ and, therefore, it should not be used to compensate the agent. In other words, the principal should only use her performance evaluation to compensate the agent.

¹⁴Note that Holmström (1979) assumes a moral hazard problem with a risk-averse agent. Chaigneau et al. (2019) extend the result to a model with limited liability and show that under risk-neutrality the principle still holds. They also show that the conditions for a signal to be of “zero value” to contracting are different from the standard informativeness principle. A signal can be of zero value even when it carries information about states where the agent obtains no compensation, which holds in our model.

¹⁵The limited liability assumption prevents the principal from offering a contract with lower compensation when the principal deems unacceptable a performance deemed acceptable by the agent, a state whose likelihood is underestimated by an agent who displays overprecision.

performance evaluation report whereas in the BPE contract it depends on both reports. The principal’s problem is to decrease as much as possible the expected wage cost for the job while preserving a good correlation between project outcome and worker compensation in order to implement high effort. When the agent is rational, the only role played by the agent’s performance evaluation is to provide incentives for truthful revelation by the principal through the imposition of a deadweight loss when the principal reports as unacceptable a performance reported as acceptable by the agent. In other words, the deadweight loss ensures the principal has an incentive to reveal an acceptable performance evaluation that results in higher compensation to the agent. Hence, the possibility of a deadweight loss makes the agent’s performance evaluation valuable in the sense of Holmström (1979).¹⁶ This is the reason why the principal’s wage cost in a BPE contract depends on both parties’ performance evaluations. In the APE contract, the agent’s performance evaluation is still valuable in the sense of Holmström (1979). But in the same fashion discussed above for the agent’s compensation, when the agent’s overprecision bias b_a is large enough, the principal can further decrease her expected wage cost by promising higher wages when the performance evaluation reports coincide and lower wages when they differ. The principal minimizes her expected wage cost maximally by making the wage cost depend only on the agent’s report.

Third, the APE contract leads to a smaller deadweight loss than the BPE contract. Recall that the deadweight loss is $(w_{ua} - c_{ua})\gamma_{ua}^H$. We know from Propositions 1 and 3 that the limited liability assumption implies that the agent’s compensation in state (u, a) is set equal to zero in the APE and BPE contracts, that is, $c_{ua}^* = c_{ua}^\dagger = 0$. Therefore, the deadweight losses of the BPE and the APE contracts are $w_{ua}^*\gamma_{ua}^H$ and $w_{ua}^\dagger\gamma_{ua}^H$, respectively. As a consequence, the contract with the lowest deadweight loss boils down to the one that pays the lowest wage in state (u, a) . Now, an agent who displays overprecision believes, mistakenly, that the (positive) correlation between

¹⁶According to Holmström (1979, pp.83): “A signal y is said to be valuable if both the principal and the agent can be made strictly better off with a contract of the form $s(x, y)$ than they are with a contract of the form $s(x)$.”

signals is higher than it actually is. As such, he expects to be in agreement with the principal more often than he should, and he expects conflict to happen less often than he should. As we have seen, the principal takes advantage of this misperception by offering a contract that promises higher wages when both performance evaluations coincide and lower wages when they differ. From this it follows that $w_{ua}^\dagger < w_{ua}^*$ and hence the APE contract leads to a smaller deadweight loss than the BPE contract. This change makes the contract more attractive to the agent since he believes, mistakenly, that agreement is more likely to happen than it actually is. Finally, this change does not violate the principal's incentive to truthfully report an acceptable performance evaluation since the higher wages in the states where the parties' performance evaluations coincide make up for lower wages in the states where they differ.¹⁷

In addition, and related to these differences, the APE contract features the highest compensation when both parties report an acceptable performance, whereas in the BPE it is enough for the principal to report $T = a$. This follows from the fact that when the agent's overprecision bias increases the principal wants to tie the agent compensation to the agent's performance evaluation so that she can wager on his bias. To do so however, she needs to grant the agent the power to impose her a high wage cost, regardless of the observed realization of T . This generates the final difference between the two contracts: in a BPE, the wage is the highest when the two parties disagree, with the agent reporting an acceptable performance and the principal reporting the opposite, while in the APE the principal pays a high wage cost if the agent reports an acceptable performance, regardless of what she observes and reports.

In order to fully describe when the APE contract is chosen by the principal we present a graphical representation of the feasible (b_a, b_u) space for an agent who

¹⁷The BPE contract sets the (TR_P^a) binding it leaves the (TR_P^u) slack. On the contrary, the APE contract features both (TR_P) binding. In other words, the smaller threat of the APE decreases the principal's truth-telling incentives to a point where both constraints become binding. If the deadweight loss following reports (u, a) were to decrease even further, the principal would no longer be reporting his performance evaluation truthfully.

displays overprecision. Figure 1 below presents the parameter space and identifies the type of contract the agent is offered for any value of his bias within the feasible space. The shaded areas rule out biases that fall outside our definition of overprecision (that is they violate (1)). In the appendix we formally prove the shape of the area where the APE contract is set up.¹⁸

We now present a Lemma that confirms a result the discussion so far has only implied: the maximum compensation in an APE contract, c_{aa}^\dagger , is greater than the maximum compensation in a BPE contract, that is, $c_{aa}^\dagger > c_{aa}^* = c_{au}^*$.

Lemma 3. *The maximum compensation available to an agent who display overprecision, c_{aa}^\dagger , is greater than the maximum ones available to either a rational or an agent who displays underprecision, $c_{aa}^* = c_{au}^*$.*

This result suggests, together with Propositions 1 and 3, a potential way to test some of the implications of overprecision. In an APE contract designed for an agent with a large enough overprecision bias b_a , the principal rewards the agent maximally only in the “best” performance evaluation case scenario, that is, when both her and the agent deem the agent’s work acceptable. In contrast, in an BPE contract designed for either a rational or an agent who displays underprecision, the principal rewards the agent maximally in situations where she deems the agent’s work acceptable. The intuition is as follows. The fact that an agent who displays overprecision overestimates the probability of state (a, a) taking place creates an

¹⁸As discussed above, it is key for an APE to be optimal that the agent believes in a strong positive correlation between signals. But this is not enough as the perceived correlation as to go in a particular direction. More specifically, as the principal is trying to implement high effort, the agent’s bias has to be such that he expects that state (a, a) is particularly likely, which happens when b_a is large enough, in particular with respect to b_u . A similar effect on perceived correlation holds for high absolute values of b_u as well, as the likelihood of state (u, u) increases to the eyes of the agent. However, a high b_u also tightens the incentive compatibility constraints. Hence, when b_u is too negative, either b_a is of a similar magnitude, or c_{aa}^\dagger in the APE becomes too large and the principal is better off offering a BPE.

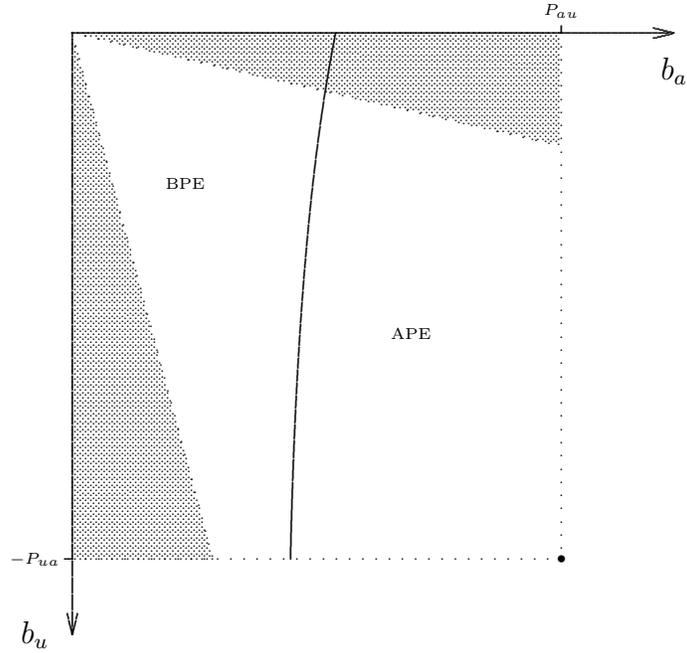


Figure 1: The area delimited by the solid curve on the right in the figure identifies the portion of the parameter space where an APE contract is set optimally for an agent who displays overprecision. The shaded areas rule out biases that fall outside our definition of overprecision. This specific graph was obtained for $(P_{aa}, P_{uu}, \Gamma_a^H, \gamma_a^G, \gamma_a^B) = (0.5, 0.4, 0.6, 0.8, 0.1)$. Its shape, however generalises to all feasible parameter values.

opportunity for the principal to wager on the agent's bias by offering him an APE contract. As we will show next, this is not necessarily a negative feature of an APE contract as it decreases the conflict at the contracting stage. Moreover, when the agent's overprecision bias b_a is moderate, so is the principal's motive to wager of the agent's bias. The agent is willing to sign an APE contract featuring a lower deadweight loss and a higher expected compensation compared to the BPE contract. However, when the agent's overprecision bias b_a is significant, he is willing to sign an APE contract where not only the deadweight loss is decreased, but his expected compensation is also lower compared to the BPE contract.¹⁹

Let $\tilde{E}(\cdot)$ denote the biased expectations of the agent.

Lemma 4. *Given the BPE and APE contracts, the following are true:*

- (i) $E(w_{ts}^*) > E(w_{ts}^\dagger)$ whenever the APE is the equilibrium contract.
- (ii) $E(c_{ts}^*) = \tilde{E}(c_{ts}^*) = \frac{\Delta V}{\Delta \Gamma_a} \Gamma_a^H$.
- (iii) $\tilde{E}(c_{ts}^\dagger) > \tilde{E}(c_{ts}^*)$ (unless $b_a = P_{au}$ when they are equal).
- (iv) $E(c_{ts}^\dagger) > E(c_{ts}^*)$ whenever

$$b_a \leq P_{au} \frac{P_{uu} - b_u \Gamma_a^H}{P_{uu}(1 + \Gamma_u^H) - b_u}, \quad (6)$$

Lemma 4 provides a set of intuitive results. First of all, part (i) obviously states that for the principal to be willing to switch to an APE contract from a BPE one, it has to be optimal for her to do so. That is, she must be paying a lower expected wage. Part (ii) follows from the fact that in the BPE contract the agent's compensation does not depend on the agent's bias. Part (iii) shows that the agent would always be happy to be assigned the APE contract instead of a BPE contract – even when the principal prefers a BPE to an APE contract. This is because an agent who

¹⁹Hence the APE may be connected to the idea of “exploitative” contracts in the literature on agents with biased beliefs (Eliaz and Spiegler 2006, 2008).

displays overprecision overestimates the chances of obtaining c_{aa}^\dagger which, as we show above, is the largest possible compensation available among the ones in the BPE and APE contracts. Finally, part (iv) is by far the most interesting and important. It shows that, even though the principal wagers on the agent's overprecision, under some conditions, the APE contract is not exploitative. If the agent's beliefs satisfy (5) and (6), the contract not only allows the principal to pay a lower expected wage, but it also features, from the perspective of an outside observer, a larger expected compensation for the agent. This sets the stage for the main welfare result of this section.

Proposition 4. *Assume the agent is overconfident in the sense of overprecision, his outside option satisfies $\bar{u} \leq \bar{u}_3$, and his beliefs satisfy (5).*

- (i) *If the agent's beliefs satisfy (6), overprecision leads to a Pareto improvement: the principal offers an APE contract that costs her a lower expected wage and grants the agent higher expected compensation than the BPE contract.*
- (ii) *If the agent's beliefs violate (6), overprecision leads to exploitation: then the principal offers an APE contract that costs her a lower expected wage and grants the agent lower expected compensation than the BPE contract. For this type of beliefs, overprecision leads to exploitation.*

We know from Proposition 3 that if the agent's overprecision bias b_a is large enough, the principal offers an APE contract. Note that when this happens, the principal's expected benefit, $\lambda^H Y$, does not depend on the agent's overprecision whereas her expected wage cost does. In addition, the agent's cost of exerting high effort, $V(\lambda^H)$, does not depend on his own bias but the agent's expected compensation does. Hence, if the principal offers an APE contract, a Pareto improvement takes place when overprecision lowers the principal's expected wage cost and at the same time, taking the perspective of an outside observer, raises the agent's expected compensation.

Proposition 4 shows that if the agent’s overprecision bias b_a is moderate, that is, his beliefs satisfy (5) and (6), the APE contract lowers the principal’s expected wage cost and raises the agent’s expected compensation. In this case, there is a Pareto improvement since overprecision makes both principal and agent better off. In contrast, if the agent’s overprecision bias b_a is significant, that is, his beliefs violate (6), the APE lowers the principal’s expected wage cost as well as the agent’s expected compensation. In this case, there is exploitation since overprecision makes the principal better off and the agent worse off. Note that by exploitation we mean a situation where the agent signs a contract he would not have signed were he rational – i.e. were he holding unbiased beliefs about the distribution of S .

This result contributes to the literature on impact of worker overprecision on the social welfare of employment relationships. The most closely related study is Gervais et al. (2011).²⁰ Gervais et al. (2011) analyze the impact of worker overprecision when the firm offers objective evaluation contract based on the project’s performance. In Gervais et al. (2011) the worker, instead of making an unobservable effort choice, decides whether the firm should pursue a project or not. The worker has access to a private signal that is informative about the probability of success or failure of the project. The worker is overconfident in the sense that he overestimates the precision of his private signal. The firm’s incentive problem is to align the worker’s investment decision with firm-value maximization. Note that this is an hidden information problem (the firm cannot observe the worker’s signal) and there is no hidden action problem (the worker’s choice to pursue the project is observable to the firm). Gervais et al. (2011) show that worker overprecision makes the firm better off since it relaxes the worker’s truthful revelation constraints. Since the worker’s participation constraint always binds in equilibrium, it follows that, taking the perspective of an outside observer, a worker who displays overprecision is worse than a rational worker. Hence, in Gervais et al. (2011), overprecision always leads to exploitation.

In our study, there is an hidden action (unobservable effort) as well as an hid-

²⁰Goel and Thakor (2008) study the effects of overprecision for CEO selection.

den information problem (due to subjective evaluation). In line with Gervais et al. (2011), we find that overprecision relaxes the worker’s truthful revelation constraints (see Appendix). In contrast, the impact of overprecision on the worker’s incentive constraint is ambiguous. However, Proposition 3 shows that when the overprecision bias is large enough, the firm is made better off since it is able to implement high effort at a lower expected wage cost. Furthermore, Proposition 5 shows that when the overprecision bias is moderate there is a Pareto improvement but when it is significant there is exploitation. Hence, we find that the impact of overprecision on social welfare under subjective evaluation contracts does not necessary lead either to exploitation or to a Pareto worsening, as is the case under objective evaluation contracts.

In the proof of the Proposition 4 we provide a formal argument to show that the region where overprecision leads to a Pareto improvement corresponds (in shape) to the one in Figure 2 below and that it always exists.

4 Effort Selection

This section discusses the impact of overprecision on the principal’s effort selection problem. It shows that the principal’s incentives to select high effort, as opposed to low effort, are weakly higher when the agent displays overprecision than when he is rational.

Our last result characterizes the effect of the agent’s overprecision on the principal’s effort selection problem. Recall that since the expected return of the project, Y , does not affect effort implementation costs, there always exists a Y large enough for the principal to select high effort over low.

Proposition 5. *When the agent’s outside option satisfies $\bar{u} \leq \bar{u}_3$, the principal’s incentives to select high effort, as opposed to low effort, are weakly higher with an agent who display overprecision than with a rational one.*

Proposition 5 shows that the agent’s overprecision makes it more attractive for the principal to select high effort, rather than low effort. This happens because an increase in the agent’s overprecision bias b_a weakly decreases the expected cost of implementing high effort without affecting the cost of implementing low effort. The intuition behind this result is as follows. As we have seen, Proposition 3 shows that an increase in the agent’s overprecision bias b_a weakly decreases the principal’s expected wage cost of implementing high effort. The proof of Proposition 5 shows that, no matter if the agent is rational or displays overprecision, the principal always chooses to implement low effort using a fixed wage-compensation contract, that has no deadweight loss, and that leaves the agent indifferent between accepting the contract and rejecting it, that is, a contract $\{w_{ts}^\ell, c_{ts}^\ell\}$ where $w_{ts}^\ell = c_{ts}^\ell = \bar{u} + V(\lambda^L)$ for all t and s . The reason why this fixed wage-compensation contract is optimal to implement low effort lies in the cost of truthful reporting. For truthful reporting to happen, none of the reports must lead to a payoff-dominant reporting strategy. In this fixed wage-compensation contract this is trivially true since the payoff is constant. Using a variable wage-compensation contract to implement low effort would lead to a higher wage cost to the principal since this would require a deadweight loss, or else at least one party would have a payoff-dominant reporting strategy.²¹

This result implies that the social benefits of an agent who displays overprecision can go beyond the framework of Proposition 4. All else equal, higher agent’s overprecision leads to (weakly) higher output – i.e. outcome Y is realized (weakly) more often. As such, not only principals are better off when facing an agent who displays overprecision, but so are all the stakeholders involved in the task. Our model therefore provides a further explanation why managers who display overprecision are more likely to obtain leading executive roles (Goel and Thakor 2008), as the board wants to maximize output and profits, and suggests that this phenomenon might in fact benefit society by increasing overall output.

²¹When the agent has a large outside option, the principal may find it optimal to implement low effort with a BPE contract. The latter is also independent of the bias, and therefore our discussion is unaltered.

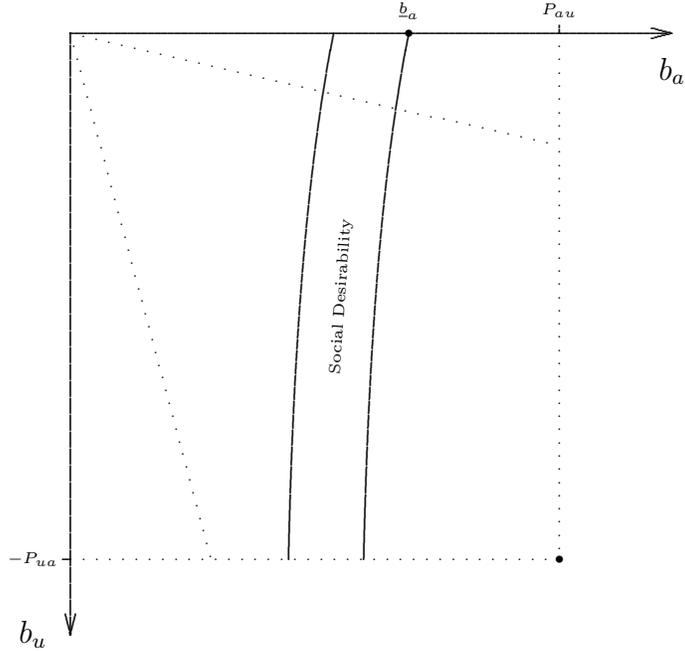


Figure 2: The area inside the two curves features a contract with a higher expected compensation and a lower expected wage compared to the benchmark contract assigned to a rational agent. Inside this area, the presence of an agent who displays overprecision is socially optimal. In the proof of Proposition 4 we provide a formal argument to show that this area always exists and it is shaped as is displayed here. The value of \underline{b}_a is also derived in the proof. Above the dotted line in the top quadrant the agent perceives signals as negatively correlated. The dotted lines in the bottom quadrant restrict the parameter space according to our definition of overprecision. This specific graph was obtained for $(P_{aa}, P_{uu}, \Gamma_a^H, \gamma_a^G, \gamma_u^B) = (0.7, 0.5, 0.6, 0.8, 0.1)$. Its shape, however generalises to all feasible parameter values.

5 Large Outside Option

This section shows that our main results extend to the whole \bar{u} space. The formal proofs can be found in the Online Appendix.

5.1 Rational Agent

When the agent is rational and has a large outside option, i.e., $\bar{u} > \bar{u}_1$, the BPE contract is no longer feasible since it violates the agent's participation constraint. In this case, the principal offers the agent a *Generalized Baseline Performance Evaluation* (GBPE) contract. The GBPE contract ensures the agent's expected compensation is exactly \bar{u} . It does so by granting the agent a minimum positive compensation in states where the principal deems the agent's performance unacceptable (as opposed to zero in the BPE). The GBPE contract has the same main features as the BPE contract: the agent's compensation depends only on the principal's performance evaluation, while the principal's wage cost depends on both parties' performance evaluations. Hence, the GBPE contract is simply an upward modification of the BPE contract.

5.2 Overestimation

When the agent displays overestimation and has a large outside option, i.e., $\bar{u} > \bar{u}_2$, the contract in Proposition 2 is no longer feasible since it violates the agent's participation constraint. In this case, the principal offers a contract that is simply an upward modification of the contract derived in Proposition 2. This contract ensures the agent's perceived expected compensation is exactly \bar{u} . It does so by granting the agent a minimum positive compensation in states where the principal deems the agent's performance unacceptable (as opposed to zero as in contract derived in

Proposition 2).

The principal is more likely to benefit from the agent's overestimation when the agent's outside option is large. In this case, the participation and the incentive effects of overestimation both play a role. We know from Santos-Pinto (2008) that under non-decreasing incentive schemes, overestimation has a favorable participation effect, i.e., it relaxes the agent's participation constraint for fixed compensation. The subjective evaluation contract is a non-decreasing incentive scheme since the agent is paid higher compensation after the principal reports an acceptable performance and lower compensation after she reports an unacceptable performance. Hence, an agent who displays overestimation overvalues the subjective evaluation contract as this offers higher compensation in states the agent overestimates and lower compensation in states the agent underestimates. In addition, as we have seen in Section 3, overestimation has a favorable incentive effect when it makes high effort more attractive to the agent for fixed compensation. Hence, when the agent's outside option is large and overestimation makes high effort more attractive, both effects are favorable to the principal and she is better off. When the agent's outside option is large and overestimation makes high effort less attractive, the incentive effect is unfavorable but the participation effect is favorable. In this case, the principal will be better off or worse off depending on which of the two effects dominates.

5.3 Overprecision

When the agent displays overprecision and his outside option is large, i.e., $\bar{u} > \bar{u}_3$, the APE contract is no longer feasible since it violates the agent's participation constraint. In this case, the principal offers the agent either the GBPE contract or a *Generalized Agent Performance Evaluation* (GAPE) contract. The GAPE contract ensures the agent's perceived expected compensation is exactly \bar{u} and has the same main features as the APE contract: the agent's compensation depends on both parties' performance evaluations, while the principal's wage cost depends only on the agent's performance evaluation. We also show that the GAPE contract can

Pareto dominate the GBPE contract.

6 Underconfidence

This section discusses the implications of underconfidence for subjective performance evaluation. The formal proofs can be found in the Online Appendix.

6.1 Underestimation

When the agent displays underestimation and his outside option is small, i.e., $\bar{u} \leq \bar{u}_1$, he is offered the contract in Proposition 2. In this case, the impact of underestimation on the optimal contract depends on whether underestimation makes high effort more or less attractive. When underestimation makes high effort more (less) attractive, the principal promises lower (higher) compensation in states where she deems the agent's performance acceptable while keeping compensation unchanged in states where she deems the agent's performance unacceptable.

When the agent displays underestimation and his outside option is large, i.e., $\bar{u} > \bar{u}_1$, the contract in Proposition 2 is no longer feasible since it violates the agent's participation constraint. In this case, the principal offers a contract that is simply an upward modification of the contract derived in Proposition 2. This contract ensures the agent's perceived expected compensation is exactly \bar{u} . It does so by granting the agent a minimum positive compensation in states where the principal deems the agent's performance unacceptable (as opposed to zero as in contract derived in Proposition 2). When underestimation has a favorable (unfavorable) incentive effect, the principal lowers (raises) compensation in states where she deems the agent's performance acceptable and raises (lowers) compensation in states where she deems the agent's performance unacceptable.

The welfare implications of underestimation depend on the agent's outside option. The principal is more likely to be adversely affected by the agent's underestimation when the agent's outside option is large than when it is small. When the agent's

outside option is large, the participation and the incentive effects of underestimation both play a role. We know from Santos-Pinto (2008) that under non-decreasing incentive schemes, underestimation has an unfavorable participation effect, i.e., it tightens the agent's participation constraint for fixed compensation. The subjective performance contract is a non-decreasing incentive scheme since the agent is paid higher compensation after the principal reports an acceptable performance and lower compensation after she reports an unacceptable performance. Hence, an agent who displays underestimation undervalues the subjective performance contract as it pays higher compensation in states the agent underestimates and lower compensation in states the agent overestimates. In addition, underestimation has an unfavorable incentive effect when it makes high effort less attractive to the agent for fixed compensation. Hence, when the agent's outside option is large and underestimation makes high effort less attractive, both effects are unfavorable to the principal and she is worse off. When the agent's outside option is large and underestimation makes high effort more attractive, the incentive effect is favorable but the participation effect is unfavorable. In this case, the principal will be better off or worse off depending on which of the two effects dominates.

6.2 Underprecision

Consider now the case of an agent who displays underprecision and has a small outside option. If such an agent believes signals are positively correlated, his beliefs satisfy (2) and (3), then he is offered a BPE contract. Recall that an agent who believes signals are positively correlated is either offered a BPE or a APE contract.²² However, underprecision means that $b_a < 0$ and $b_u \in \left(-\frac{\gamma_a^G}{\gamma_u^G} b_a, -\frac{\gamma_a^B}{\gamma_u^B} b_a\right)$. Furthermore, we know that $b_u \leq P_{uu}$. These conditions imply that if an agent who displays underprecision believes signals are positively correlated, then his beliefs violate (5) and therefore he is always offered a BPE contract. Hence, when an agent who displays underprecision believes signals are positively correlated, his bias neither leads to an

²²This follows from Lemma (13) in the Appendix.

APE contract nor to a new type of contract.

However, this is no longer the case when underprecision is strong enough to change the direction of signal correlations perceived by the agent. When this happens he expects his performance evaluation realization to be the opposite from that of the principal. But since the latter is informative towards the outcome of the project, it means that the agent assigns informative value to his own performance evaluation as well. He just assigns the “wrong” one. Furthermore, the agent may think that an unacceptable realization of his own performance evaluation, S , is a signal of a good outcome ($\tilde{\Pr}\{S = u|G\} > \tilde{\Pr}\{S = u|B\}$), while an acceptable one is a signal of a bad outcome ($\tilde{\Pr}\{S = a|B\} > \tilde{\Pr}\{S = a|G\}$). Hence, when an agent who displays underprecision believes signals are negatively correlated, his beliefs are subject to odd interpretations. For this reason, we relegate the analysis of this case to the Online Appendix and present a short summary here:

1. The presence of a deadweight loss in the contract is no longer a necessary condition to implement high effort.
2. An agent who displays underprecision and believes signals are weakly negatively correlated is offered a BPE contract.
3. An agent who displays underprecision and believes signals are strongly negatively correlated is offered one of two new types of contract. We call these: the *Disagreement Performance Evaluation Deadweight Loss* (DPE-DL) contract and the *Disagreement Performance Evaluation No Deadweight Loss* (DPE-NDL) contract. These contracts feature no compensation in states where the parties observe the same performance evaluation, states the agent deems very rare. Hence, the principal can exploit the agent’s biased beliefs by compensating the agent only in states where they observe different performance evaluations.
4. The DPE-NDL contract features no deadweight loss and it is available only under certain parameter configurations.

These results point towards an interesting insight. While we do confirm the findings of previous contributions on how overprecision and underprecision, have different implications for optimal contracting, we show that optimal subjective evaluation contracts are, to some extent, symmetric when it comes to the direction and intensity of perceived correlation. Regardless of the direction, when perceived correlation is particularly strong the principal has the ability to manipulate the contract and decrease the cost of incentivizing the agent to exert the amount of effort required.

As derived in the Online Appendix, our welfare analysis extends to the case of an agent who displays underprecision and believes signals are negatively correlated. There exists a parameter space where the DPE-DL contract is a Pareto Improvement over the BPE contract. Interestingly, however, the DPE-NDL contract, the one featuring no deadweight loss, never Pareto Improves over the BPE contract and is always exploitative. This is because for the deadweight loss to be completely erased, it must be that the agent is so biased that he will be exploited. Needless to say, the DPE-NDL contract features the lowest (that is zero) deadweight loss, while the DPE-DL contract can be shown to always feature a lower deadweight loss than a BPE contract.

7 Conclusion

This paper shows that worker overconfidence has implications for the optimal design of subjective evaluation contracts. These implications are different when the worker displays overestimation than when the worker displays overprecision, two commonly observed types of overconfidence.

The optimal subjective evaluation contract offered to a worker who displays overestimation differs from that offered to a rational worker. Worker overestimation can make the firm better off and the worker worse off, leading to exploitation. This depends on the participation and incentive effects of overestimation. The participation effect is always favorable to the firm since the worker's compensation is increasing

with the firm's performance report. When worker overestimation makes high effort more attractive to the worker, overestimation has a favorable incentive effect and the firm is better off. When worker overestimation makes high effort less attractive to the worker, overestimation has an unfavorable incentive effect. In this case, the firm is better off or worse off depending on the sizes of the participation and the incentive effects of overestimation.

The optimal contract for a worker who displays overprecision can be quite different to the optimal contract for a rational worker. When the worker's overprecision bias is large enough, the firm offers a contract that wagers on the worker's bias by promising more in states where the parties' performance evaluations coincide and less in states where they differ. Interestingly, this contract uses the worker's performance evaluation as an input to set the worker's compensation. This is a novel result in the subjective evaluation literature and might explain why boards and compensation committees often use a CEO's self-appraisal as an input to set the CEO's compensation. Worker overprecision can lead to either a Pareto improvement or to exploitation. Finally, worker overprecision can make it more attractive for the firm to select high effort instead of low.

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