Moral hazard with optimistic managers

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Abstract

Managers with anticipatory emotions have higher current utility if they are optimistic about the future. We study an employment contract between an (endogenously) optimistic manager and realistic investors. The manager faces a trade-off between ensuring that the chosen levels of effort reflect accurate news and savoring emotionally beneficial good news. Investors and manager agree over the optimal news recall when the manager's weight on anticipatory utility is low. For intermediate values, there is a conflict of interest and investors bear an extra-cost to have the manager recalling a bad signal. For high weights on anticipatory utility, investors become indifferent between inducing signal recollection or not, and the optimal contract is a pooling equilibrium reminiscent of adverse selection models. Finally, to underline the relevance of psychological testing for human resource selection, we study the role played by emotions in the manager's selection process both when investors know the manager's psychological trait and when they don't.

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1 Introduction

It is widely believed that over-optimism is a common feature between human beings. This psychological trait is even more common among businessmen (De Meza and Southey, 1996). For instance, as suggested by Roll (1986), over-optimism may explain an excess of merger activity. Overconfident CEOs overestimate their ability to generate returns. As a result, they overpay for target companies and undertake value-destroying mergers. Malmendier and Tate (2005, 2008) identify evidence of the CEO's over-estimation of their firm future performance, in their holding stock options until the expiration date.[1] The fact that wishful beliefs show up not only in words but also in deeds, is for Bénabou (2009) the proof that reality denial is not or at least not only a managers' attempt to deceive investors.

This paper studies an employment contract between a manager with anticipatory emotions and investors who responds strategically to those emotions. Moreover, the paper also looks at the role played by this psychological trait on the manager's selection. Managers with anticipatory emotions have higher current utility if they are optimistic about the future. However, such optimism affects decisions because distorted beliefs distort actions.

How is this psychological trait affected by monetary incentives?

Our model considers a setting in which risk neutral investors hire a risk neutral manager for a project. When the investors offer the contract to the manager, the parties are symmetrically informed. If the manager accepts, in carrying out the task he was hired for, he will choose a level of effort that will affect the project's probability of success. After signing the contract, but before choosing the unobservable effort influencing the project's return, the manager receives a private signal about the profitability of the task. A good signal implies a high project's return in case of success, while a bad signal implies only an intermediate return. Finally, the same low return is obtained in case of failure following both signals. If the signal is informative about the return from effort, the manager would benefit from knowing accurate news. However, if the manager derives utility from the anticipation of his final payoff, the suppression of a bad signal may induce a positive

[1] Also Cooper et al. (1988) find that entrepreneurs see their own chances for success higher than that of their peers.

interim emotional effect. We assume that investors cannot observe the agent's choice. Thus, in order to induce the manager to choose the right action, they can offer a reward that is contingent on the project revenue. More specifically, the parties can write a complete contract specifying the rewards contingent on the possible outcomes, the effort levels to be exerted contingent on the signals and the probability that bad news will be remembered accurately. Does the optimal contract always ensure complete recall?

We show that there is no conflict of interest between the investors and the manager's desired recall when the manager's psychological trait – measured by a parameter weighting the anticipatory utility – is sufficiently low. For intermediate values of this parameter, there is a conflict of interest and investors choose to bear the extra-cost necessary to have the manager recall the bad signal. Finally, for a sufficiently high weight on anticipatory utility, investors become indifferent between inducing signal recollection or not, and the optimal contract is characterized by a pooling equilibrium reminiscent of adverse selection models.

Why does the optimal contract looks like this? Informed managers face a trade off between ensuring that the chosen level of efforts reflect accurate news and savoring an emotionally beneficial good news. However, the manager's preferred level of memory may differ from the investors' one. As a result, in writing the contract, the investors may want to affect also this dimension of the manager's choice. If in the manager's total utility the weight on emotions is sufficiently low, accurate news is a priority also for the manager and there is no conflict of interest between the investors and the manager with respect to information recollection. Then, a contract can be written that attains the optimal recall at no extra cost.[2] For higher weights attached by the manager to anticipatory utility, the manager's trade off between accurate news and good news tilts in favor of the latter, so that enticing information recollection from the manager becomes costly. For intermediate values of the parameter investors choose to affect the manager's trade off in favor of accuracy by making costly recalling a good signal when the true signal is bad: this is done by increasing the cost the manager incurs when he exerts the effort expected for the good signal rather than the one for

[2]No extra cost with respect to the resources needed to solve the moral hazard problem.

the bad signal. If the weight on emotions instead is sufficiently high the optimal contract calls for a pooling equilibrium where the manager exerts the same level of effort and receives the same payments following both good and bad signals. Intuitively, when the weight on anticipatory utility is large, the manager will accurately recall the signal only if he does not anticipate a lower payment when the signal is bad.[3]

The common practice in many institutions, industries and businesses of using psychological testing for human resources selection – including the screening of emotional aspects – induces to ask what is the role played by emotional characteristics on the investors' hiring policy? The analysis has, so far, implicitly relied on the assumption that investors know the weight attached by the manager to anticipatory utility. In this case, investors would indifferently hire any manager whose anticipatory utility implies no conflict of interest between the investors and the manager's desired recall. However, even if psychological testing makes this assumption an interesting benchmark, we extend the analysis to the somewhat more realistic situation in which the psychological parameter is the manager's private information. In this latter case, the optimal contract is characterized by a threshold such that all managers with a weight below it would recall the bad signal while those with a weight above the threshold would forget it. It is worth noticing that – with private information – all managers would be hired and the set of those induced to recall the bad signal will be larger than in the perfect information benchmark, including also those managers who due to the conflict of interest impose to the investors an extra-cost to recall.

This paper is related to two strands of the literature that link economics and psychology. The first centers on cognitive dissonance, endogenous self-confidence and anticipatory feelings.[4] The second deals with over-confidence or over-optimism in firms.[5]

However, none of these papers has asked the question we face here: what does it look like in

[3] There exist also an outcome equivalent equilibrium where the investors prefer not to entice information recollection from the manager, the manager never recalls the bad signal and exerts the same level of effort as in the pooling equilibrium.

[4] Akerlof and Dickens (1982), Brunnermeier and Parker (2005), Bénabou and Tirole (2002), Caplin and Leahy (2001) Carrillo and Mariotti (2000) and Koszegi (2006).

[5] Bénabou (2009), Bénabou and Tirole (2003), Cooper et al. (1988), De Meza and Southey (1996), Fang and Moscarini (2005), Gervais and Goldstein (2007), Landier and Thesmar (2008), Landier, Sraer and Thesmar (2009), Malmendier and Tate (2005, 2008), Roll (1986), Rotemberg and Saloner (1993).

a moral hazard setting the optimal contract between a manager who can became prey of over-optimism and investors who respond strategically to those emotions? Two related papers are Bénabou and Tirole (2003), and Fang and Moscarini (2005). In the former, within a setting in which the agent will undertake a certain task only if he has sufficient confidence in his own ability to succeed, the authors study how an informed principal should reward the agent knowing that rewards can undermine intrinsic motivation. Similarly, in the latter, wage contracts provide both incentives and affect work morale, by revealing the firm's private information about workers skills. Unlike these papers, in our analysis both parties are ex-ante symmetrically informed. Finally, Landier and Thesmar (2008) suggest differences in opinion between realistic investors and optimistic entrepreneurs as a new determinant of the firm's capital structure. In a financial contracting framework, they show that optimistic entrepreneurs make more use of short-term debt and test this prediction on a large sample of small startups finding evidence that short term debt is correlated with optimism.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 studies the manager's optimal choices of effort and awareness. Section 4 presents our result on the conflict of interest between the investors and the manager's optimal recall. Section 5 characterizes the optimal contract. Section 6 identifies the manager's type s investors would choose if they were allowed to do so, and extends the analysis to the case in which the weight s is the manager's private information. Section 7 concludes. All proofs are in the Appendix.

2 The model

Players and environment

Consider a setting in which a risk neutral investor hires a risk neutral manager for a project that has three possible outcomes, $\widetilde{v} \in \{v_0, v_L, v_H\}$, with $v_0 < v_L < v_H$. In carrying out the task he was hired for, the manager chooses a level of effort a affecting the probability of success, with $a \in [0; 1]$. The effort has disutility $c(a)$, with $c(0) = 0$, $c'(a) \geqslant 0$, $c''(a) > 0$ and $c'''(a) \geq 0$. In order to ensure interior solutions, we also assume that $c'(0) = 0$ and $c'(1) \geq v_H$. After signing the contract but before choosing the effort level, the manager receives a private signal $\sigma \in \{L; H\}$ correlated with the project's return $\tilde{v}$. The probability that a good signal H is received is q, whereas the probability that a bad signal L is received is $(1-q)$, with $q \in [0;1]$. In our setting, good (bad) news means that the outcome is v_H (v_L) or v_0 with probability a and $1-a$, respectively. In other words, we assume for simplicity that the signal is perfectly correlated with the return $\tilde{v}$, implying that:

$$\Pr(\tilde{v} = v_0 | \sigma = L) = \Pr(\tilde{v} = v_0 | \sigma = H) = 1 - a,$$

and

$$\Pr(\tilde{v} = v_L | \sigma = H) = \Pr(\tilde{v} = v_H | \sigma = L) = 0.$$

Then, ex-ante v_0, v_L and v_H can each arise with probabilities $1-a, (1-q)\,a$ and qa, respectively. From now on, for the sake of semplicity and without loss of generality, we normalize $v_0 = 0$.

Given that the signal is informative about the return from effort, the manager would benefit from knowing accurate news when choosing a. However, if the manager derives utility from the anticipation of his final payoff, the suppression of a bad signal may induce a positive emotional effect. More specifically, we assume that total utility is a convex combination of actual (as of time 3) and anticipated physical outcomes (as of time 2), with weights $1-s$ and s, respectively.

In line with Bénabou and Tirole (2002), we assume that at the time of the effort decision a bad signal can be forgotten due to voluntary repression. We then denote by $\widehat{\sigma} \in \{L; H\}$ the recollection, at the time of the effort decision, of the news σ and by $\lambda \in [0;1]$ the probability that bad news will be remembered accurately, that is, $\lambda \equiv \Pr(\widehat{\sigma} = L | \sigma = L)$. We assume that the manager can, at no cost, increase or decrease the probability of remembering an event.[6] Finally, we denote by "Manager 1" the manager's self at time 1 and by "Manager 2" the manager's self at time 2.

The manager's action is not directly observable by the investors. Hence, to induce the manager to choose the "right" action, they can only offer rewards contingent on the observable and verifiable project revenues. We denote by $C \equiv \{w_0, w_L, w_H\}$ the contract investors offer the manager, where w_i is the reward corresponding to $v = v_i$, for any $i = 0, L, H$. We assume that the manager

[6] Assuming costly recollection would not change our qualitative results.

has limited liability so that $w_i \geq 0$ for any i.[7] Finally, we maintain the standard assumption of individuals as rational Bayesian information processors.[8] Both investor and manager are assumed to be completely Bayesian, given what they know about the economic environment.

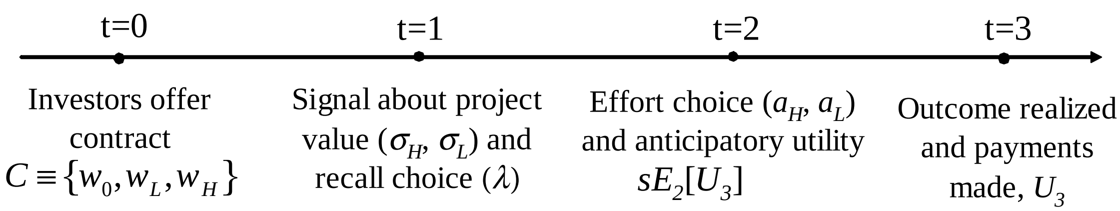


Fig. 1: Time-line

Timing

The precise sequence of events depicted in figure 1 unfolds as follows:

t=0: Investors offer a contract C to the manager to run a project.

t=1: If manager 1 refuses the contract, the game ends. Instead, if he accepts the contract, he observes a private signal σ and, when the signal is bad ($\sigma = L$), chooses the probability λ that the bad news will be remembered accurately.

t=2: Manager 2 observes $\widehat{\sigma}$, updates his beliefs on the outcome v, selects the effort level a and enjoys the anticipatory utility experienced from thinking about his future prospects.

t=3: The project payoff is realized and the payment is executed.

Equilibrium concept

We shall look for the Subgame Perfect Nash Equilibrium (SPNE) of this game. To compute the equilibrium, we first identify the optimal manager's effort choice a, given his beliefs about σ and a contract C. Then, we describe the perfect Bayesian equilibrium of the memory game for any given contract. In the perfect Bayesian equilibrium of the memory game: i) for any realized σ, manager 1 chooses his message $\widehat{\sigma}$ to maximize his expected utility, correctly anticipating what

[7] All our results generalize to the case of unlimited liability.
[8] In doing this assumption we follow most of the literature quoted above.

inferences he will draw from $\widehat{\sigma}$, and what action he will choose; ii) manager 2 forms his beliefs using Bayes rule to infer the meaning of manager 1's message, knowing his strategy. Finally, we use the optimal manager's effort choice rule and the equilibrium in the memory game to compute the optimal contract offered by the investor to the manager.

3 Effort choice and the memory game

To study the impact of incentives on the manager's optimal recall probability and effort level, we consider the subgame starting in $t = 1$. We take as given the compensation contract $C \equiv \{w_0, w_L, w_H\}$ and analyze under which conditions the manager prefers to perfectly remember his private signal on v. We study the equilibrium of the memory game in three stages.

Manager 2's inference problem

At the beginning of period 2, the manager observes a recollection of the signal on the distribution of the project's revenue $\widehat{\sigma}$, which depends on the news received in the previous period σ, and on how his previous-self processed them, that is on λ. The manager is aware that there are incentives in manipulating memory. Hence, faced with a memory $\widehat{\sigma} \in \{L; H\}$, he has to assess its credibility. Bayesian rationality implies that when $\widehat{\sigma} = L$ the manager knows that the state is L. On the other hand, when $\widehat{\sigma} = H$ the manager's posterior belief is:

$$\Pr(\sigma = H|\widehat{\sigma} = H, \lambda) = \frac{q}{q + (1-q)(1-\lambda)} \equiv r(\lambda) \in [q, 1] \,, \tag{1}$$

where λ is his equilibrium recall probability.

Manager 2's choice of effort

The manager chooses a level of effort that maximizes his intertemporal expected utility. Denoting by E_2 the expectation at $t = 2$, the intertemporal utility perceived by the manager as of time $t = 2$, given the memory $\widehat{\sigma}$ and the compensation contract C, is:

$$E_2 \left[U(C, a, \lambda)|\widehat{\sigma}\right] = -c\,(a) + E_2 \left[u(C, a)|\widehat{\sigma}\right] , \tag{2}$$

where $c(a)$ is the disutility of effort, and $E_2[u(C,a)|\widehat{\sigma}]$ is the sum between the manager's material payoff $(1-s)E_2[u(C,a)|\widehat{\sigma}]$, and his anticipatory utility experienced by savoring the future material payoff, $sE_2[u(C,a)|\widehat{\sigma}]$. When $\widehat{\sigma}=L$, the expected payoff simplifies to:

$$E_2[u(C,a)|L] = aw_L + (1-a)\,w_0.$$

Instead, when $\widehat{\sigma}=H$, the expected payoff is:

$$E_2[u(C,a)|H] = a\,(rw_H + (1-r)w_L) + (1-a)\,w_0.$$

We denote the manager's optimal strategy at $t=2$ for any $r \in [q;1]$ and for any $C \in R^3_+$ by $a(r,C) \equiv \{a_L, a_H(r)\}$, where a_L and $a_H(r)$ are the effort levels that maximize the managers' expected utility when signals L and H, respectively, are recalled.

Manager 1's recall choice

By assumption, when the true signal is good, $\sigma = H$, manager 1's recollection will be always accurate, that is, $\widehat{\sigma}=H$. Instead, when the true signal is bad, $\sigma=L$, the manager chooses the probability λ that bad news will be remembered accurately so as to maximize the expected utility of his payoff at time $t=1$, that is:

$$E_1[U(C,a(r,C),\lambda)] = E_1[-c\,(a(r,C)) + sE_2[u(C,a(r,C))]] + (1-s)\,E_1[u(C,a(r,C))]\,,$$

where E_1 denotes expectations at $t=1$. Since the manager prefers to recall bad news only when

$$E_1[U(C,a(r,C),1)|\sigma=L] \geq E_1[U(C,a(r,C),\lambda)|\sigma=L]\,,$$

then λ will be equal to 1 only if[9]

$$[(a_L w_L + (1-a_L)\,w_0) - c\,(a_L)] \geq \tag{3}$$

$$[s\,(a_H(r)\,(rw_H + (1-r)\,w_L) + (1-a_H(r))\,w_0) + (1-s)\,(a_H(r)w_L + (1-a_H(r))\,w_0) - c\,(a_H(r))]\,.$$

[9] Notice the difference between $E_1[u(C,a(r,C))] = a_H(r)w_L + (1-a_H(r))\,w_0$ and $E_2[u(C,a(r,C))]] = a_H(r)\,(rw_H + (1-r)\,w_L) + (1-a_H(r))\,w_0$ that derives from the different information available in $t=1$, i.e., the true information and the recollected one available in $t=2$.

At equilibrium $r = r(\lambda)$, so that the previous condition simplifies to

$$\underbrace{c\left(a_H(\lambda)\right) - c\left(a_L\right)}_{\text{extra cost of effort}} \geq \underbrace{s a_H(\lambda) r(\lambda)\left(w_H - w_L\right)}_{\text{emotional gain from forgetting}} + \underbrace{\left(a_H(\lambda) - a_L\right)\left(w_L - w_0\right)}_{\text{indirect gain from higher effort}}, \tag{4}$$

where $a_H(\lambda) \equiv a_H(r(\lambda))$. From the previous analysis we conclude that the manager has an incentive to remember when, for any $\lambda < 1$, the extra-cost he incurs to exert effort $a_H(\lambda)$ rather than a_L exceeds the emotional gain from forgetting, due to the uncertainty about the true project return in case of success, plus the anticipatory and material benefit of obtaining w_L rather than w_0 with an increased probability $(a_H(\lambda) - a_L)$. For given rewards, the equilibrium of the memory subgame depends on s. Indeed, when the weight of the emotional gain from forgetting is low the cost of exerting higher effort exceeds the benefits from forgetting bad news more often. The converse is true for high value of s. [10] To simplify the analysis, we assume that, in case of multiplicity, the manager will choose the Pareto-superior equilibrium, that is the one preferred by the investor. Finally, we denote by $\lambda(C)$ the optimal λ for any $C \in R^3_+$.

4 The conflict over the optimal recall between investors and manager

In this section we show the existence of a potential conflict of interest between investor and manager over the preferred memory strategy. In the previous section, we have seen that, whenever the weight on anticipatory utility s is large, the emotional gain from forgetting (see 4) may drive the manager to forget a bad signal. Now, we show that, unlike the manager, investors always prefer perfect recall.

We proceed in two steps. First, we solve the investors' maximization problem under the assumption that λ is exogenously given and is common knowledge. Second, we find the optimal level of λ from the investors' point of view. Given that the manager's effort is not observable, investors must offer an incentive compatible contract that induces the manager to choose the level of effort desired by the investor.

Faced with the contract C and the recalled signal $\widehat{\sigma}$, the manager chooses an effort $a_{\widehat{\sigma}}$ such

[10] For further details we refer to Bénabou and Tirole (2002).

that:

$$a_{\widehat{\sigma}} = \arg \max_{a \in [0,1]} E_2 \left[U(C, a, \lambda) | \widehat{\sigma} \right]. \tag{5}$$

By the strict concavity of the manager's objective function, a necessary and sufficient condition for the incentive constraint to be satisfied when $\widehat{\sigma} = L$ is the following:

$$(w_L - w_0) = c' \left(a_L \right).^{11} \tag{6}$$

Instead, when $\widehat{\sigma} = H$, the necessary and sufficient condition is:

$$(r(\lambda) w_H + (1 - r(\lambda)) w_L - w_0) = c' \left(a_H \right).^{12} \tag{7}$$

Finally, we denote by $a(r(\lambda), C) \equiv \{a_L, a_H(\lambda)\}$ the vector of efforts which solve problem (5) for $\widehat{\sigma} \in \{L, H\}$.[13]

When investors make their offer, the manager does not know σ. Thus, to induce the manager to accept the offer, the contract has to satisfy the following ex ante participation constraint:

$$\begin{gathered} E_0 \left[U \left(C, a(r(\lambda), C), \lambda \right) \right] = q E_1 \left[U(C, a(r, C), \lambda) | \sigma = H \right] + (1 - q) E_1 \left[U(C, a(r, C), \lambda) | \sigma = L \right] = \\ \left[w_0 + q a_H \left(w_H - w_0 \right) + (1 - q) \left(\left(1 - \lambda \right) a_H + \lambda a_L \right) \left(w_L - w_0 \right) \right] + \\ - \left((1 - \lambda \left(1 - q \right)) c \left(a_H \right) + \lambda \left(1 - q \right) c \left(a_L \right) \right) \geq 0, \end{gathered} \tag{8}$$

where E_0 denotes the expectation at time $t = 0$. Finally, by the limited liability constraints, the manager's transfer must be always positive, that is:

$$w_i \geq 0 \ \forall i \in \{0, L, H\}. \tag{9}$$

If a $\lambda-$type manager accepts the contract C, the principal expected profit in period 0 is:

$$\begin{gathered} E_0 \left[\Pi \left(C, a(r(\lambda), C), \lambda \right) \right] = \sum_{i \in \{0, L, H\}} \Pr \left(v_i | C, a, \lambda \right) \left(v_i - w_i \right) = \\ q a_H \left(v_H - \left(w_H - w_0 \right) \right) + (1 - q) \left(\left(1 - \lambda \right) a_H + \lambda a_L \right) \left(v_L - \left(w_L - w_0 \right) \right) - w_0, \end{gathered} \tag{10}$$

where $q a_H = \Pr_0 \left(v_H | \lambda \right)$, and $(1 - q) \left(\left(1 - \lambda \right) a_H + \lambda a_L \right) = \Pr_0 \left(v_L | \lambda \right)$.

[11] Where $(w_L - w_0) \in [c'(0), c'(1)]$.

[12] Where $(r(\lambda) w_H + (1 - r(\lambda)) w_L - w_0) \in [c'(0), c'(1)]$.

[13] Assuming that $c'(0) = 0$ and $c'(1) \geq v_H$ ensures interior solutions.

The investors' problem boils down to the choice of effort levels a_H, a_L and payments w_H, w_L and w_0 that maximize their expected profits (10) subject to the incentive constraints (6) and (7), the participation constraint (8), and the limited liability constraints (9). Let us denote by P^λ the investors programme for given λ. It is interesting to notice that moral hazard and limited liability make delegation costly to investors. To be more precise, let us define the $\lambda-$first best world as a setting where effort is observable and λ is exogenously given. The limited liability constraints reduce the set of incentive feasible allocations and prevent the investors from implementing the $\lambda-$first best level of effort even with a risk-neutral manager.[14]

Hence, by solving program $\mathcal{P}^\lambda$, with both the limited liability constraint on w_0 and the incentive constraints (6) and (7) binding, investors reach their $\lambda-$second best expected utility $E_0\Pi^{\lambda SB}(\lambda) = E_0\left[\Pi\left(C^{\lambda SB}, a(r(\lambda), C^{\lambda SB}), \lambda\right)\right]$. The next proposition shows that the accuracy of the manager's information is always valuable for investors.

Proposition 1 *An increase in the probability that bad news will be remembered accurately λ has a positive effect on the investors' $\lambda-$second best expected utility, $E_0\Pi^{\lambda SB}(\lambda)$.*

As information becomes more precise, i.e., λ grows, a_H increases because the manager's expected benefit from exerting effort when he recalls a good signal raises (see equation (7)). This involves a positive indirect effect for investors due to the increase in the probability of success both following a good signal (qa_H) and a bad signal ($(1-q)\left((1-\lambda)\, a_H + \lambda a_L\right)$). However, in the latter case, an increase in λ increases the weight on a_L and decreases the one on a_H, implying a negative direct effect on the probability of success. Proposition 1 makes clear that the positive indirect effect overcomes the negative one, implying that if investors could choose the manager's type they would prefer a manager with λ equal to 1. Let us denote by C^{SB} the second-best contract solving programme $\mathcal{P}^\lambda$ when $\lambda = 1$. Then, next proposition shows that managers with sufficiently high anticipatory emotions will prefer to forget bad news when offered contract C^{SB}.

[14] Without the limited liability constraints, the $\lambda-$first best outcome might be obtained through a contract which rewards the manager in case of success (i.e., $w_H > 0$ and $w_L > 0$) and punishes him otherwise (i.e., $w_0 < 0$). However, the constraint on transfers limits the investors' ability to punish the manager.

Proposition 2 *If the weight on anticipatory utility s is sufficiently high, the manager always prefers to forget bad news when rewarded with contract C^{SB}.*

Taken together, Propositions (1) and (2) underline a potential conflict in a setting where λ is endogenously chosen: investors always prefer perfect signal recall, while the manager, if the weight of anticipatory utility is high, could prefer to forget bad news.

For simplicity, from now on we assume that $c(a) = ca^2/2$, with $c \geq v_H$.[15] This allows us: first, to find an explicit condition on the parameter s for the contract C^{SB} to implement the second-best outcome; and second, to characterize the third-best outcome when there is a conflict between investor and manager over the optimal λ.

In order to compute the $\lambda-$second best levels of effort and rewards, we solve problem $\mathcal{P}^{\lambda}$ under the assumption of quadratic costs. We set $w_0 = 0$ (because of the limited liability constraint) and solve (6) and (7) for w_L and w_H. Substituting in the objective function (10), differentiating with respect to a_H and a_L, and solving gives:

$$a_H^{SB}(\lambda) = \frac{r(\lambda)\, v_H + (1 - r(\lambda))\, v_L}{2c} \tag{11}$$

$$a_L^{SB} = \frac{v_L}{2c}, \tag{12}$$

where v_L and $r(\lambda)\, v_H + (1 - r(\lambda))\, v_L$ are the gains from effort when a good and a bad signal is observed, respectively. Since the marginal benefit of effort is larger when the manager recalls a good signal than when he recalls a bad one (i.e., $r(\lambda)\, v_H + (1 - r(\lambda))\, v_L \geq v_L$), then in the former case the level of effort implemented by investors is larger. Moreover, the marginal benefit of effort when good news is recalled increases with the accuracy of information. As a consequence, $a_H^{SB}(\lambda)$ increases with λ.

Using (11), (12) and $w_0 = 0$ in the incentive constraints we get:

$$w_H^{SB} = \frac{v_H}{2} \tag{13}$$

$$w_L^{SB} = \frac{v_L}{2}. \tag{14}$$

[15] This condition ensures interior solutions.

Interestingly, the $\lambda-$second best rewards are independent from λ. Incentives to induce a $\lambda-$type manager to exert effort when good news are recalled depend on λ through the expected rewards in the case of success rather than through each state contingent payment.

Using the $\lambda-$second best payments and effort levels in the investors' objective function (43) and differentiating with respect to λ, in tune with proposition 1, we find that investors always prefer the manager to recall a bad signal:

$$\frac{\partial E_0 \Pi^{SB}(\lambda)}{\partial \lambda} = \frac{q^2 (1-q)(v_H - v_L)^2}{4c(1-\lambda(1-q))^2} > 0.$$

Moreover, using the second-best payments (13), (14) and $w_0 = 0$ in constraint (4), with $\lambda = 0$, and solving for s, we find that the manager would choose $\lambda = 1$ only if:

$$s \leq s_1 \equiv \frac{q(v_H - v_L)}{2(qv_H + (1-q)v_L)} < \frac{1}{2}. \tag{15}$$

The threshold s_1 is the highest weight on anticipatory utility which makes the manager indifferent between recalling and forgetting bad news.[16] Notice that since the ratio in (15) is less than 1/2, condition (4) is violated if $s > 1 - s$, that is whenever the weight on anticipatory utility is greater than the one on physical outcome.

5 The optimal contract

We explore now the implications of a violation of condition (15) on the optimal contract. In the previous section, we have found that for $s \leq s_1$ investors' and manager's preferences over λ are perfectly aligned, so that the second-best contract $C^{SB} = \{0; v_L/2; v_H/2\}$ satisfies the non-forgetfulness constraint (4) and implements the second best levels of effort:[17]

$$a_H^{SB} = \frac{v_H}{2c} \tag{16}$$

[16] Under the hypothesis of quadratic costs, the set of values of s for which the manager is indifferent between recalling and forgetting bad news is an interval. For any s in this interval, there are three equilibria: $\lambda = 0$, $\lambda = 1$ and one in which memory is partially selective (i.e., $0 < \lambda < 1$). Since we assumed that, in case of multiplicity, the manager chooses the equilibrium preferred by the investor, for any s lower than s_1 there will be perfect recall in equilibrium.

[17] Notice that (16) comes from (11) for $\lambda = 1$. Moreover, it is simple to check that the participation constaint (8) is satisfied by these second-best payments and efforts.

$$a_L^{SB} = \frac{v_L}{2c}. \tag{17}$$

Instead, if the manager attaches a large weight on anticipatory utility, that is if $s > s_1$, the second-best outcome cannot be implemented because contract C^{SB} fails to induce the manager to correctly recollect his private information. This gives rise to a third-best in which effort is unverifiable and the manager chooses to forget bad news. In such circumstances, the investors's problem is to choose a vector of effort levels and a contract that solve programme $\mathcal{P}^\lambda$ with $\lambda = 1$, under the further constraint that the manager is indifferent between forgetting and recalling bad news. Let us denote by $\mathcal{P}^{TB}$ the investors' programme in this third-best world.

In order to induce the manager to recall the signal, investors offer a contract that satisfies the non-forgetfulness constraint (4) (for $\lambda = 0$) with equality. In this case the non-forgetfulness constraint (4) simplifies to:[18]

$$(a_H - a_L)\left[(1-2s)\, q\,(a_H - a_L) - 2sa_L\right] = 0. \tag{18}$$

Satisfaction of the previous equality gives rise to two possible equilibria: a *separating* one, denoted by the superscript S, where $a_L = \frac{(1-2s)q}{q+2s(1-q)} a_H$, which is possible only if $s \leq 1/2$, and a *pooling* one, denoted by the superscript P, where $a_H = a_L$.[19] The next proposition describes the solution of the investors' problem in these two non-forgetful equilibria.

Proposition 3 *In the separating equilibrium, the optimal levels of effort are:*

$$a_H^S = a_H^{SB} + \gamma \frac{(1-2s)(1-q)}{c}, \;\; a_L^S = a_L^{SB} - \gamma \frac{q + 2s(1-q)}{c},$$

and are implemented by the following state-contingent rewards:

$$w_0^S = 0, \;\; w_H^S = w_H^{SB} + \gamma (1-2s)(1-q), \;\; w_L^S = w_L^{SB} - \gamma (q + 2s(1-q)),$$

where $\gamma \equiv \frac{(qv_H + (1-q)v_L)}{[q+4s^2(1-q)]}(s - s_1)$ *is positive for any* $s \geq s_1$.

In the pooling equilibrium, the optimal level of effort is given by:

$$a_H = a_L = a^P = qa_H^{SB} + (1-q)\, a_L^{SB},$$

[18] See the proof of Proposition 3 for details.

[19] If $s > 1/2$, the binding non-forgetfulness constraint (18) would imply $a_L < 0$.

and is implemented by the following state-contingent rewards:

$$w_0^S = 0, w_H = w_L = w^P = q w_H^{SB} + (1-q)\, w_L^{SB}.$$

The previous proposition makes clear that there are two opposite ways to entice signal recollection by the manager. In the separating equilibrium investors choose to increase the cost of forgetting, that is the left-hand side of equation (4). This is done by asking for a level of effort higher than the second-best one when the manager recalls good news and instead for a level of effort lower than the second-best one when he recalls bad news. In order to implement those effort levels which are further apart, a manager recollecting a good (bad) signal must be offered a reward higher (lower) than the second-best one.[20] In the pooling equilibrium, instead, investors remove any incentive to suppress bad news by offering a flat contract paying a constant amount w^P irrespective of the result $\{v_H, v_L\}$ and asking for the same level of effort a^P following both signals. Given that neither effort levels nor rewards depend on signal recollection, the manager is indifferent between recalling or forgetting bad news.[21]

The next proposition states conditions on parameters for the separating or the pooling equilibrium to arise.

Proposition 4 *The separating equilibrium arises for all* $s \in (s_1;\ 1/2]$*, whilst the pooling equilibrium arises for all* $s > 1/2$*.*

The pooling equilibrium always arises if $s > (1-s)$. Indeed, in this case, the separating equilibrium would entail a negative level of effort when the bad signal is observed. Since, by assumption, the level of effort has to be between 0 and 1, we should have $a_L^S = 0$. However, in this case, the investors' expected profit would be greater in the pooling equilibrium. Thus, when facing a manager who attaches a weight on anticipatory emotions larger than to physical utility, investors

[20] It is simple to check that in the separating equilibrium the distance between both effort levels and rewards when the good and the bad signals are observed grows with respect to the second best. Indeed, since a separating contract is offered only if $s \geq s_1$, and since γ is positive for any $s \geq s_1$, it is immediate to see that: $a_H^S > a_H^{SB}$ and $w_H^S > w_H^{SB}$, while $a_L^S < a_L^{SB}$ and $w_H^S < w_H^{SB}$.

[21] It is interesting to observe that in the pooling equilibrium a^P is the average between a_H^{SB} and a_L^{SB}, and w^P is the average between w_H^{SB} and w_L^{SB}.

always offer a pooling contract. On the other hand, if $s \leq (1-s)$ the separating equilibrium always arises since $E_0\Pi^S - E_0\Pi^P \geq 0$ for all $s \leq 1/2$.

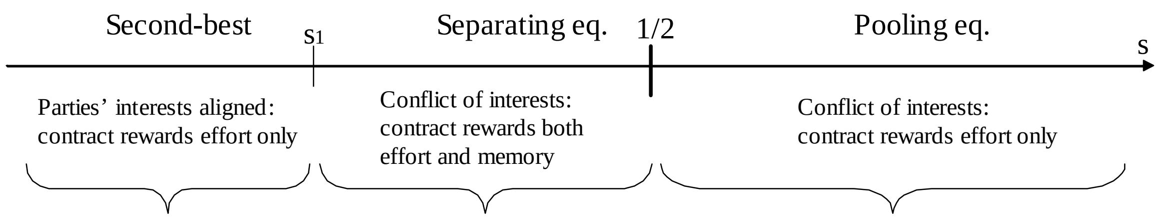


Fig. 2: Optimal contract as a function of the manager's weight on anticipatory utility

Thus, depending on the manager's weight on anticipatory utility, we can have the three scenarios depicted in figure 2. When s is sufficiently low ($s \leq s_1$), the manager correctly recalls the signals received ($\lambda = 1$) and investors design a contract that rewards effort, but not memory. Due to moral hazard, investors achieve the second-best. For $s_1 < s \leq 1/2$, the emotional impact of bad news may induce the manager to suppress it and recall good news instead. To induce memory recollection, investors have to design a separating contract that punishes forgetfulness and rewards memory. This is achieved by setting payments and effort levels farther apart.[22] However, when $s > 1/2$, investors stop distorting efforts and payments to induce signal recollection and choose a different strategy to achieve their goal. Specifically, they offer a flat contract paying w^P for effort a^P irrespective of the level of output $\{v_H, v_L\}$, thereby removing any incentive to suppress bad news. When $s > 1/2$, a separating contract is infeasible because a_L goes negative. The weight of emotions is so high that it is impossible for investors to keep on limiting the distortion through an incentive contract. The incentive contract hits a physical limit. In this case investors choose to "weaken" the weight played by emotions in the manager's behavior by offering him a flat contract.

Finally, there exists also an outcome equivalent equilibrium in which investors prefer not to entice information recollection from the manager because too costly. In these cases investors opt for an *accommodating* strategy that accepts the manager's forgetfulness ($\lambda = 0$), by neglecting constraint (4), so that the manager never recollects the bad signal. As a result the manager always

[22] It is immediate to check that $\Delta w^S = w_H^S - w_L^S > w_H^{SB} - w_L^{SB} = \Delta w^{SB}$ and $\Delta a^S = a_H^S - a_L^S > a_H^{SB} - a_L^{SB} = \Delta a^{SB}$.

exerts high effort a_H^A, and a_L is out of the equilibrium path. It turns out that $a_H^A = a^P$ and $w_H^A = w^P$ so that this equilibrium is welfare equivalent to the pooling one (see the Appendix for details).

6 Manager's selection

It is common practice in many institutions, industries and businesses to use psychological testing for human resources selection including the screening of emotional aspects such as 'emotional stability'. Emotional stability is one of the main psychological trait studied by The Big 5 Personality Model, which has become a widely accepted and used system of personality assessment. This psychological trait describes how someone confronts and handles events or stressors that cause pressure. Intense people are prone to feeling their emotions with passion. They tend to respond to stress in an alert, attentive, or excitable way. Steady individuals seem impervious to negative stimulation. They likely respond in a calm, seemingly emotion-less manner. If investors (and more generally employers) can learn about the emotional stability of managers – which looks so akin to the psychological trait of our paper – it is natural to ask what is the role played by such emotional characteristics for the investors' hiring policy? We study first what happens if investors know the weight attached by the manager to anticipatory utility. Next, we extend the analysis to study the other extreme case in which the weight s is the manager's private information and we show how the optimal contract varies when this feature is introduced in the baseline model developed above.

6.1 The investors' preferred s

The optimal contract offered to a manager with $s \leq s_1$ and the level of effort he chooses are independent from s. Indeed, if the preferences over the memory strategy of investors and manager are perfectly aligned, the weight that the latter attaches to emotions with respect to physical utility does not affect the effort decisions. As a consequence, the investors' second-best expected utility does not depend on s and is given by:

$$E_0 \Pi^{SB} = q \, \frac{v_H^2}{4c} + (1 - q) \, \frac{v_L^2}{4c}. \tag{19}$$

Instead, whenever investors and manager disagree over the optimal λ, that is for all $s_1 < s \leq 1/2$, both rewards and effort levels depend on s. Indeed, the manager's incentives to forget bad news are larger when the weight of emotions is high, then the distortion of efforts and payments necessary to induce signal recollection grows with s and the third-best investors' expected profits in the separating equilibrium decreases with s. The next proposition shows this result.

Proposition 5 *For all $s \in (s_1;\ 1/2]$,* i) *the distance between w_H^S and w_L^S increases with s,* ii) *the distance between a_H^S and a_L^S increases with s, and* iii) *the investors' expected utility, $E_0\Pi^S$, decreases with s.*

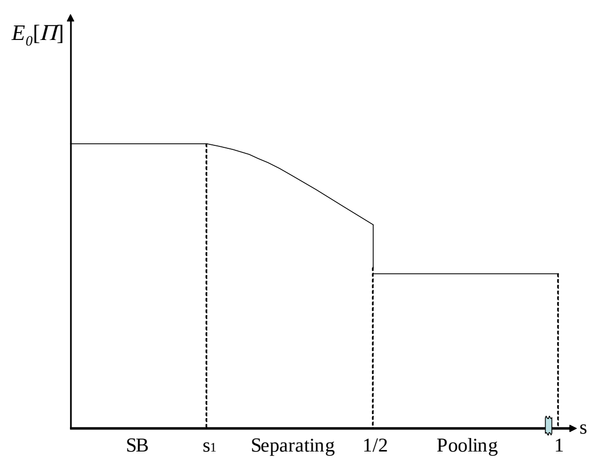
Finally, in the pooling equilibrium, investors stop distorting rewards to induce memory recollection and neither efforts nor payments are affected by the weight that the manager attaches to emotions. Consequently, in the pooling equilibrium the investors third-best expected utility does not depend on s and is given by:

$$E_0\Pi^P = E_0\Pi^{SB} - \frac{q\,(1-q)\,(v_H - v_L)^2}{4c}. \tag{20}$$

The next proposition compares the investors' utility for all s and allows to conclude that if investors could observe s they would choose any manager with s smaller than s_1.

Proposition 6 *The investors' expected utility is weakly decreasing in s.*

The pattern of utility for varying s is depicted in the following figure:



Invetsors' expected utility as a function of s

6.2 Manager's private information

Even if tests for employment screening are common practice, assuming that investors perfectly know the weight s attached by the manager to the anticipatory utility is a rather strong assumption. We extend the previous analysis to account for the case where the weight s is the manager's private information and we look at the effect of this setup modification on the optimal contract and selection. If s is the manager's private information, investors cannot offer a contract contingent on s (second-best, separating, or pooling contract). For any contract $C = \{w_0, w_L, w_H\}$, both the prefered recall strategy and the chosen level of efforts will now depend on the manager's type s.

Let us denote by $\widehat{S}$ a subset of $[0,1]$ such that all managers with $s \in \widehat{S}$ prefer to recall their private information when offered the contract C. Then, the investors' decision problem, $\mathcal{P}^{AI}$, is to choose the set $\widehat{S}$, the level of efforts and the contract C that maximize their expected profits, subject to the limited liability constraints, the incentive constraints, the participation constraints (both for recalling and forgetful managers) and the non forgetful constraint for all managers with $s \in \widehat{S}$. Moreover, let a_L and $a_H(1)$ be the level of efforts of a manager with $s \in \widehat{S}$, when he observes bad and good news, respectively. Instead, let $a_H(0)$ be the level of effort of a manager who prefers to forget bad news whenever offered contract C, that is a manager with $s \notin \widehat{S}$.

As in the complete information benchmark, the binding limited liability constraint gives $w_0 = 0$. Substituting $w_0 = 0$ in the manager' s incentive constraints (6 and 7) and assuming that the manager prefers to recall the bad signal – i.e., $\lambda = 1$, we obtain:

$$w_L\left(a_L\right) = c\, a_L, \tag{21}$$

and

$$w_H\left(a_H(1)\right) = c\, a_H(1). \tag{22}$$

Then, substituting $w_0 = 0$, (21) and (22) in the incentive constraint for a forgetful manager, that is (7) with $\lambda = 0$, we obtain:

$$a_H(0) = q\frac{w_H}{c} + (1-q)\,\frac{w_L}{c} = q a_H(1) + (1-q)\, a_L. \tag{23}$$

Finally, the contract offered by the investors has to be such that all mangers with $s \in \widehat{S}$ prefer to recall the signal, something that is insured if we impose the non-forgetfulness constraint (4) for all $s \in \widehat{S}$. However, the non-forgetfulness constraint (4) is equivalent to $a_L \leq \phi(s) a_H(1)$ for all $s \in \widehat{S}$, where $\phi(s) \equiv \frac{(1-2s)q}{q+2s(1-q)}$. Then, defining $\widehat{s} \equiv \sup \widehat{S}$ and noticing that $\phi(s)$ is decreasing in s, this condition is clearly satisfied for all $s \in \widehat{S}$ if and only if:

$$a_L \leq \phi(\widehat{s}) a_H(1) \equiv a_L(a_H(1)). \tag{24}$$

To simplify the analysis of the investors' decision problem, we assume that s is uniformly distributed on $[0, 1]$ and we show in the next Lemma that $\widehat{S}$ is an interval.

Lemma 1 *Assume that s is manager's private information; then the optimal contract is such that all managers with $s \leq \widehat{s}$ will recall a bad signal while those with $s > \widehat{s}$ will forget it.*

Then, the investors expected profit can be written as:

$$\begin{aligned} &\int_0^{\widehat{s}} [q\, a_H(1)\, (v_H - w_H) + (1-q)\, a_L (v_L - w_L)] ds + \\ &+ \int_{\widehat{s}}^1 a_H(0)\, [q\, (v_H - w_H) + (1-q)\, (v_L - w_L)] ds - w_0. \end{aligned} \tag{25}$$

Substituting $w_0 = 0$, (21), (22) and (23) in (25) and rearranging terms we get:

$$\begin{aligned} E_0 [\Pi (a_H(1), a_L, \widehat{s})] = [a_H(1) q (v_H - c a_H(1)) + a_L (1-q)(v_L - c a_L)] \widehat{s} + \\ + [a_H(1) q + a_L(1-q)][q(v_H - c a_H(1)) + (1-q)(v_L - c a_L)](1 - \widehat{s}). \end{aligned} \tag{26}$$

Thus, the investors' problem simplifies to the choice of $a_H(1)$, a_L and $\widehat{s}$ that maximize (26), subject to constraint (24).[23] The following Proposition states the main result of the section.

Proposition 7 *Assume that s is manager's private information; then the optimal contract is such that all managers will accept the investors' offer and the threshold beetween recalling and forgetting the bad signal is $\widehat{s} \in (s_1;\ 1/2]$.*

The intuition for the previous result relies on a better understanding of the investors expected profits in expression (26). The overall investors profits are the average between those deriving from

[23] In the Appendix we show that the participation constraints both for recalling and forgetful managers are always positive and can be ignored.

managers who choose to recall the bad signal and those deriving from managers who choose to forget it. For the latter group, investors prefer not to entice information recollection opting for an *accommodating* strategy that accepts the manager's forgetfulness ($\lambda = 0$), by neglecting constraint (4). Then, a threshold $\widehat{s} < s_1$ is never optimal because offering the second best contract C^{SB} to all managers will induce those with $s \leq s_1$ to recall the bad news and, at the same time, will maximize the profits coming from the managers who choose to forget. Second, we know from the previous section that for all $s_1 < s \leq 1/2$, the emotional impact of bad news may induce the manager to suppress it and recall good news instead. To induce memory recollection, investors had to design a costly separating contract that punishes forgetfulness and rewards memory. Then, it may seem surprising that the optimal contract with imperfect information is such that investors decide to induce recollection also from managers with $s > s_1$. However, for those managers whose weight is slightly above s_1 the extra cost of inducing recallaction is small while the increase in profits switching from accomodating to separating is big. In other words, the direct effect of an increase in the threshold $\widehat{s}$ is first order while the indirect effect travelling via the non-forgetful constraint is second order.

7 Conclusions

Managers with anticipatory emotions have higher current utility if they are optimistic about the future. We studied an employment contract between an (endogenously) optimistic manager and a realistic investor. After having documented the existence of a potential conflict between investors and manager over the memory strategy, we have shown that manager's optimism may be affected by monetary incentives. More specifically, we have found that for sufficiently low managerial's anticipatory emotions, investors' and manager's preferences over optimal recall are perfectly aligned, so that the second-best contract C^{SB} solving the moral hazard problem also satisfies a non-forgetfulness constraint. Instead, if the manager attaches a large weight on anticipatory utility, the second-best outcome cannot be implemented because contract C^{SB} fails to induce the manager to correctly recall his private information. This gives rise to a third-best world in which investors must distort efforts and payments to make the manager indifferent between forgetting and recalling bad news. Moreover, we study the role played by emotions in the manager's selection process both when investors know the manager's psychological trait and when they don't.

What happens in our setting if effort is verifiable? If payments are contingent on the outcome, so that a better outcome is associated with a higher payment, the manager will always have an incentive to forget bad news. To prevent this, investors can offer a flat contract and obtain the first-best utility. In other words, a second imperfection, besides an emotional manager is necessary to make our analysis interesting.

To conclude, we think that our theory has interesting implications for managerial compensation and selection. For instance, our analysis suggests a motivation for imposing a cap on managerial compensations when investors face a highly optimistic manager and underlines the relevance of psychological testing for human resource selection.

A Appendix

Proof of Proposition 1

In order to solve problem $\mathcal{P}^{\lambda}$, we derive w_0 from the binding limited liability constraint, solve the incentive constraints with respect to w_L and w_H, substitute $w_0 = 0$, $w_L(a_L)$ and $w_H(a_H)$ in the objective function and maximize with respect to a_L and a_H. By combining (6) and $w_0 = 0$ we have:

$$w_L(a_L) = c'(a_L). \tag{27}$$

From (6), (7) and $w_0 = 0$, we obtain:

$$w_H(a_H; a_L) = \frac{(1-\lambda(1-q))c'(a_H) - (1-\lambda)(1-q)c'(a_L)}{q}. \tag{28}$$

Substituting $w_0 = 0$, (27) and (28) in (10) and rearranging, the objective function becomes:

$$\begin{aligned} E_0[\Pi(a_L, a_H)] \quad = \quad & q a_H v_H + (1-q)((1-\lambda) a_H + \lambda a_L) v_L + \\ & -(1-\lambda(1-q)) a_H c'(a_H) - \lambda(1-q) a_L c'(a_L). \end{aligned} \tag{29}$$

Differentiating (29) with respect to a_L and a_H, we have the following necessary and sufficient conditions:

$$\frac{\partial E_0[\Pi(a_L, a_H)]}{\partial a_L} = v_L - \left(c'\left(a_L^{SB}\right) + a_L^{SB} c''\left(a_L^{SB}\right)\right) = 0 \tag{30}$$

$$\frac{\partial E_0[\Pi(a_L, a_H)]}{\partial a_H} = \frac{q}{(1-\lambda(1-q))}(v_H - v_L) + v_L - \left[c'\left(a_H^{SB}(\lambda)\right) + a_H^{SB}(\lambda) c''\left(a_H^{SB}(\lambda)\right)\right] = 0 \tag{31}$$

By the envelope theorem, the derivative of the investors' expected profits with respect to λ is:

$$\frac{\partial E_0\left[\Pi\left(a_L^{SB}, a_H^{SB}(\lambda)\right)\right]}{\partial \lambda} = (1-q)\left[a_L^{SB}(v_L - c'(a_L^{SB})) - a_H^{SB}(\lambda)(v_L - c'(a_H^{SB}(\lambda)))\right],$$

that is positive only if:

$$a_L^{SB}(v_L - c'(a_L^{SB})) > a_H^{SB}(\lambda)(v_L - c'(a_H^{SB}(\lambda))). \tag{32}$$

Define the function $f(a) \equiv a(v_L - c'(a))$, with first derivative given by $f'(a) = v_L - (c'(a) - ac''(a))$, and observe that:

- $f'(a_L^{SB}) = 0$ by (30) and $f'(a_H^{SB}(\lambda)) < 0$ by (31),
- $f''(a) = -2c''(a) - ac'''(a) < 0$ for any a, since $c''(a) \geq 0$ and $c'''(a) \geq 0$ by assumption.

Hence, $f(a)$ is decreasing for any $a \in [a_L^{SB}; a_H^{SB}(\lambda)]$ and condition (32) is satisfied. $\square$

Proof of Proposition 2

From the analysis of the memory game, we know that three situations can occur, depending on parameters. Either the manager strictly prefers to recall the signal and the game has the unique equilibrium $\lambda = 1$, or the manager strictly prefers to forget the signal and the game has the unique equilibrium $\lambda = 0$, or the manager is indifferent between recalling and forgetting the signal and the game has three equilibria: $\lambda = 1$, $\lambda = 0$ and $0 < \lambda < 1$. In this last case, we assumed that the prevailing equilibrium is the one preferred by investors that is, from Proposition 1, $\lambda = 1$. As a consequence, for any given contract C^{SB}, we can simply consider manager's pure strategies. Thus, by setting $\lambda = 0$ and rearranging terms, condition (4) becomes:

$$c\left(a_H(0)\right) - c\left(a_L^{SB}\right) \geq s[a_H(0)(qw_H^{SB} + (1-q)w_L^{SB}) - a_L^{SB} w_L^{SB}] + (1-s)\left(a_H(0) - a_L^{SB}\right) w_L^{SB}, \quad (33)$$

where $a_H(0)$ is the solution to the following equation:

$$\left(qw_H^{SB} + (1-q)w_L^{SB}\right) = c'\left(a_H(0)\right). \quad (34)$$

By using (6) and (34) in (33) and rearranging terms, gives:

$$c\left(a_H(0)\right) - c\left(a_L^{SB}\right) \geq s[a_H(0)c'\left(a_H(0)\right) - a_L^{SB} c'\left(a_L^{SB}\right)] + (1-s)\left(a_H(0) - a_L^{SB}\right) c'\left(a_L^{SB}\right). \quad (35)$$

If $s = 0$, (33) becomes:

$$a_L^{SB} c'\left(a_L^{SB}\right) - c\left(a_L^{SB}\right) \geq a_H(0)c'\left(a_L^{SB}\right) - c\left(a_H(0)\right),$$

that is always true since a_L^{SB} is the maximum of the function $g(a) = a\, c'\left(a_L^{SB}\right) - c\left(a\right)$.

If $s = 1$, (33) becomes:

$$a_L^{SB} c'\left(a_L^{SB}\right) - c\left(a_L^{SB}\right) \geq a_H(0)c'\left(a_H(0)\right) - c\left(a_H(0)\right),$$

that is never true since $a_H(0) > a_L^{SB}$ and the function $h(a) = a\, c'\left(a\right) - c\left(a\right)$ is increasing in a ($h'(a) = c''(a) > 0$ by assumption). □

Proof of Proposition 3

In order to induce the manager to recall the signal, investors offer a contract that satisfies the non-forgetfulness constraint (4) (for $\lambda = 0$) with equality. Substituting $w_0 = 0$, (6) and (7) in (4) and recalling that, for $\lambda = 0$ we have $r(\lambda) = q$ and $a_H(0) = qa_H + (1-q)a_L$, the non-forgetfulness constraint (4) simplifies to:

$$(a_H - a_L)\left[(1-2s)\, q\,(a_H - a_L) - 2sa_L\right] = 0. \tag{36}$$

Satisfaction of the previous equality for $a_H \neq a_L$ gives rise to $a_L(a_H) = \frac{(1-2s)q}{q+2s(1-q)} a_H$. In order to solve the investors' problem in the separating scenario when costs are quadratic, we derive w_0 from the binding limited liability constraint, we substitute $a_L(a_H) = \phi\, a_H$, with $\phi = \frac{(1-2s)q}{q+2s(1-q)}$, in the incentive constraints and solve with respect to w_L and w_H. Finally, we substitute $w_0 = 0$, $w_L(a_H)$, $w_H(a_H)$ and $a_L(a_H)$ in the objective function and maximize with respect to a_H.

Substituting $a_L(a_H)$ and $w_0 = 0$ in (6) and solving with respect to w_L, we obtain:

$$w_L\,(a_H) = c\, a_L(a_H). \tag{37}$$

Substituting $w_0 = 0$ and $\lambda = 1$ in (7) and solving with respect to w_H, we have:

$$w_H\,(a_H) = c\, a_H. \tag{38}$$

Substituting $\lambda = 1$, $a_L(a_H)$, $w_0 = 0$, (37) and (38) in (10) and rearranging terms, the objective function becomes:

$$E_0\left[\Pi\,(a_H)\right] = qa_H\left[v_H - c\, a_H\right] + (1-q)\,\phi\, a_H\left[v_L - c\,\phi\, a_H\right]. \tag{39}$$

Deriving with respect to a_H, we have the following necessary and sufficient condition:

$$\frac{\partial E_0\left[\Pi\,(a_H)\right]}{\partial a_H} = q\left[v_H - 2c\, a_H\right] + (1-q)\,\phi\left[v_L - 2c\,\phi\, a_H\right] = 0 \tag{40}$$

Solving (40) with respect to a_H gives:

$$a_H^S = \frac{qv_H + (1-q)\,\phi v_L}{2c\,(q + (1-q)\,\phi)} \tag{41}$$

Substituting (41) in $a_L(a_H)$, in (37) and in (38) and rearranging terms we obtain the effort levels and payments in the proposition.

In order to solve the investors' problem in the pooling scenario, we derive w_0 from the binding limited liability constraint and impose $a_L = a_H$. Substituting $a_L = a_H = a$ and $w_0 = 0$ in (7) and in (6), we have:

$$w_H\,(a) = w_L\,(a) = c\, a. \tag{42}$$

Substituting $\lambda = 1$, $a_L = a_H = a$, $w_0 = 0$, and (42) in (10) and rearranging terms, the objective function becomes:

$$E_0 \left[\Pi \left(a\right)\right] = q\, a\, v_H + (1-q)\, a\, v_L - c\, a^2. \tag{43}$$

Deriving with respect to a, we have the following necessary and sufficient condition:

$$\frac{\partial E_0 \left[\Pi \left(a\right)\right]}{\partial a} = q\, v_H + (1-q)\, v_L - 2c\, a = 0 \tag{44}$$

Solving (44) with respect to a and considering that $a_L^P = a_H^P = a$, we obtain:

$$a_H^P = a_H^P = \frac{(qv_H + (1-q)v_L)}{2c}. \tag{45}$$

Substituting (45) in (42) and rearranging terms we obtain the effort level and payments in the proposition. □

Proof of Proposition 4.

Substituting out a_H^S in (39) and a_H^P in (43) we obtain the investors expected profit in the separating and pooling equilibrium respectively, i.e., $E_0\Pi^S$ and $E_0\Pi^P$. By equating $E_0\Pi^S$ and $E_0\Pi^P$ and solving for s, after some tedious algebra we obtain

$$s_2 = \frac{(v_H - v_L)\left(qv_H + (1-q)\, v_L\right)}{v_L \cdot v_H + (v_H - v_L)\left(qv_H + (1-q)\, v_L\right)}.$$

Recalling that the separating equilibrium can arise only if $s \leq 1/2$ (otherwise $a_L^S < 0$) and noticing that $s_2 > 1/2$, we conclude that the separating equilibrium arises for all $s \in (s_1;\ 1/2]$, whilst the pooling equilibrium arises for all $s > 1/2$. □

Proof of Proposition 5.

i) $\Delta w^S = (v_H - v_L)/2 + \gamma$, then:

$$\partial(\Delta w^S)/\partial s = \partial(\gamma)/\partial s = \frac{\left(qv_H + (1-q)\, v_L\right)\left(q + 4s\, s_1(1-q)\right)}{\left[q + 4s^2\left(1-q\right)\right]^2} > 0.$$

ii) $\Delta a^S = (v_H - v_L)/2c + \gamma/c$, then:

$$\partial(\Delta a^S)/\partial s = (1/c) \cdot \partial(\gamma)/\partial s > 0.$$

iii) $\partial E_0\left[\Pi^S\right]/\partial s = -\frac{2q(1-q)}{(q+2s\,(1-q))^2}\, a_H^S \left[v_L - 2c\, a_H^S\, \phi\right]$, that is lower than zero for each $s \geq s_1$, since:

$$v_L - 2c\, a_H^S\, \phi \geq 0 \iff v_L \geq -2w_L^S \iff v_L \geq v_L - 2\gamma\left(q + 2s\left(1-q\right)\right),$$

that is true for all $s \geq s_1$. $\square$

Proof of Proposition 6

The result immediately arises by direct comparison of $E_0\Pi^{SB}$ in (19), $E_0\Pi^{P}$ in (20) and $E_0\Pi^{S}$ which is obtained substituting out a_H^S in (39). $\square$

Proof of Lemma 1

Suppose, by contradiction, that there exists a manager with $s = s' < \widehat{s}$ which prefers to forget bad news. Since the contract offered by the investors is the same for all managers, from the incentive constraints (21), (22) and (23), we know that the levels of effort chosen by each manager do not depend on his type. Then, a manager with $s = s'$ prefers to forget bad news only if $a_L \geq \phi(s')a_H(1)$, which is possible only if $s' \geq \widehat{s}$ since $a_L \leq \phi(\widehat{s})a_H(1)$ and $\phi(s)$ is decreasing. This contradicts our assumption and implies that $\widehat{S} = [0; \widehat{s}]$. $\square$

Proof of Proposition 7

We start showing that all contracts with $w_0 = 0$ that satisfy constraints (21), (22) and (23), satisfy also the partecipation constraints. The participation constraint of a manager with $s \in \widehat{S}$ is:

$$q\left(a_H(1)w_H - \frac{c\,a_H^2(1)}{2}\right) + (1-q)\left(a_L w_L - \frac{c\,a_L^2(1)}{2}\right).$$

By substituting $w_0 = 0$, (21) and (22) it becomes:

$$q\frac{c\,a_H^2(1)}{2} + (1-q)\,\frac{c\,a_L^2}{2},$$

which is always positive. Similarly, by substituting $w_0 = 0$, (21), (22) and (23) in the participation constraint of a manager with $s \notin \widehat{S}$, gives:

$$a_H(0)\left(qw_H + (1-q)\,w_L\right) - \frac{c\,a_H^2(0)}{2} = \frac{c}{2}\left(qa_H(1) + (1-q)\,a_L\right),$$

that is always positive.

Now, we show that constraint (24) is binding in equilibrium. Suppose, by way of obtaining a contradiction that this is not true. If (24) is not binding, the expected profit of investors (26) is linear in s and:

$$\frac{\partial E_0\left[\Pi\left(a_H(1),\, a_L,\, \widehat{s}\right)\right]}{\partial \widehat{s}} = q(1-q)(a_H(1) - a_L[(v_H - ca_H(1)) - (v_L - ca_L)] \tag{46}$$

The optimal $\widehat{s}$ is 1 if (46) is positive and is 0 otherwise. However, $\widehat{s}=1$ is not possible since a_L cannot be negative and constraint (24) would require $a_L \leq \phi(1)a_H(1) < 0$. On the other hand, if $\widehat{s}=0$, the first order conditions on $a_H(1)$ and on a_L would imply $a_H(0) = (qv_H + (1-q)\,v_L)\,/2c$. It is easy to verify that the second best level of efforts (16) and (17) which satisfy the first order conditions are such that (46) is positive. Thus, $\widehat{s} \in (0;\,1/2]$ and constraint (24) is binding in equilibrium.

In the following we show that the optimal $\widehat{s}$ is greater than s_1. Substituting (24) in (26) and rearranging terms gives:

$$\begin{aligned} E_0\left[\Pi\left(a_H(1),\,\widehat{s}\right)\right] &= a_H(1)[q(v_H - ca_H) + (1-q)\phi(\widehat{s})(v_L - c\phi(\widehat{s})a_H(1))]\widehat{s} + \\ &+ a_H(1)[q + (1-q)\phi(\widehat{s}))[q(v_H - ca_H(1)) + (1-q)(v_L - c\phi(\widehat{s})a_H(1))](1-\widehat{s}) \end{aligned} \tag{47}$$

The problem of investors becomes to choose $a_H(1) \in [0;\,1]$ and $\widehat{s} \in (0;\,1/2]$ that maximize (47).

By deriving (47) with respect to $a_H(1)$ we have the following necessary and sufficient condition for an interior solution:

$$\begin{aligned} \frac{\partial E_0\left[\Pi\left(a_H(1),\,\widehat{s}\right)\right]}{\partial a_H(1)} &= -\frac{2qa_H(1)(q + 4\widehat{s}^3(1-q))c}{(q+2s(1-q))^2} + \\ &+ \frac{q(2(1-q)(v_H - v_L)\widehat{s}^2 + qv_H + (1-q)v_L)(q + 2(1-q)\widehat{s})}{(q+2s(1-q))^2} = 0. \end{aligned}$$

Solving with respect to $a_H(1)$, we obtain:

$$a_H(1)(\widehat{s}) = \frac{(2(1-q)(v_H - v_L)\widehat{s}^2 + qv_H + (1-q)v_L)(q + 2(1-q)\widehat{s})}{2(q + 4(1-q)\widehat{s}^3)c}. \tag{48}$$

Substituting (48) in (47), deriving with respect to $\widehat{s}$ and rearranging terms gives the following necessary and sufficient condition for an interior solution:

$$\begin{aligned} \frac{\partial E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]}{\partial \widehat{s}} &= \frac{q(1-q)\widehat{s}(2(q + (1-q)\widehat{s}^3)(v_H - v_L) - 3(qv_H + (1-q)v_L)\widehat{s})}{c(q + 4(1-q)\widehat{s}^3)} \cdot \\ \cdot \frac{(2(1-q)(v_H - v_L)\widehat{s}^2 + qv_H + (1-q)v_L)}{c(q + 4(1-q)\widehat{s}^3)} &= 2a_H(1)(\widehat{s})\,\frac{q(1-q)\,\widehat{s}}{c(q + 4(1-q)\widehat{s}^3)}\,\varphi(\widehat{s}) = 0, \end{aligned} \tag{49}$$

with $\varphi(\widehat{s}) = 2(q + (1-q)\widehat{s}^3)(v_H - v_L) - 3(qv_H + (1-q)v_L)\widehat{s}$. Since in equilibrium $a_H(1)(\widehat{s}) > 0$, the first order condition (49) for an interior solution reduces to $\varphi(\widehat{s}) = 0$. Observe that:

$$\varphi'(\widehat{s}) = 6(1-q)\widehat{s}^2(v_H - v_L) - 3(qv_H + (1-q)v_L) \leq 0 \quad \Longleftrightarrow \quad -s_3 \leq \widehat{s} \leq s_3,$$

with $s_3 \equiv \sqrt{\frac{qv_H + (1-q)v_L}{2(v_H - v_L)(1-q)}}$. Hence, the function $\varphi(\widehat{s})$ is decreasing for all $\widehat{s} \in [0;\,s_3]$, increasing for all $\widehat{s} > s_3$ and the point $\widehat{s} = s_3 > 0$ is a local minimizer of $\varphi(\widehat{s})$. This implies that the function

$E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$, in the interval $(0;\,1/2]$, has at the most one interior local maximizer that we denote by s_M. Moreover:

$$\varphi(s_1) \propto \frac{1}{2} + q^3(1-q)\frac{(v_H - v_L)^3}{4(qv_H + (1-q)v_L)^3} > 0$$

and, since $\varphi(\widehat{s})$ is decreasing for all $\widehat{s} < s_1$ because $s_3 > s_1$, then $\varphi(\widehat{s}) > \varphi(s_1) > 0$ for all $\widehat{s} < s_1$ and the optimal $\widehat{s}$ is always greater than s_1.

To conclude we show that, depending on the parameters, the global maximizer of $E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$ can be either $\widehat{s} = s_M \leq 1/2$, or $\widehat{s} = 1/2$. Note that:

$$\varphi(1/2) = \frac{v_H(1+q) - v_L(7+q)}{4} \leq 0 \quad \Longleftrightarrow \quad \frac{v_L}{v_H} \geq \frac{(1+q)}{(7+q)} \equiv r_1(q)$$

and, since $\varphi(s_1) > 0$ and $\varphi(\widehat{s})$ is decreasing for all $\widehat{s} \leq s_3$ and increasing for all $\widehat{s} > s_3$, this implies that for all $\frac{v_L}{v_H} \geq r_1(q)$ there exists a unique $s_M \in (s_1;\,1/2]$ such that $\varphi(s_M) = 0$ and the global maximizer of $E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$ is $\widehat{s} = s_M$.

Result 1: For all $\frac{v_L}{v_H} \geq r_1(q)$, the optimal $\widehat{s}$ is the interior maximizer $s_M \in (s_1;\,1/2]$.

On the other hand, for all $\frac{v_L}{v_H} < r_1(q)$, $\varphi(1/2) > 0$ and, then, $\widehat{s} = 1/2$ is a border local maximizer. Observe that:

$$\varphi(s_3) = 2q(v_H - v_L) - 2(qv_H + (1-q)v_L)\sqrt{\frac{qv_H + (1-q)v_L}{2(v_H - v_L)(1-q)}}.$$

Tedious algebraic calculus shows that:

$$\varphi(s_3) \geq 0 \;:\Longleftrightarrow\quad q \leq 2/3 \;\; and \;\; \frac{v_L}{v_H} \leq \frac{(2q^2(1+q))^{(\frac{1}{3})} - q}{(1 - q + (2q^2(1+q))^{(\frac{1}{3})})} \equiv r_2(q) \tag{50}$$

and

$$r_1(q) - r_2(q) \propto 1 + 7q - 6(2q^2(1+q))^{(\frac{1}{3})} \geq 0 \;\; for \;\; all \;\; q < 2/3. \tag{51}$$

Result (50) implies that the function $E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$ has no interior local maximizer when q is lower that 2/3 and $\frac{v_L}{v_H} \leq r_2(q)$ since his derivative is always positive. Result (51) implies that 1/2 is a border local maximizer of the function $E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$ when q is lower that 2/3 and $\frac{v_L}{v_H} \leq r_2(q)$. By combining (50) and (51) we can conclude that when $q \leq 2/3$ and $\frac{v_L}{v_H} \leq r_2(q)$ the global maximizer is $\widehat{s} = 1/2$.

Finally, when $q \leq 2/3$ and $\frac{v_L}{v_H} > r_2(q)$ and when $q > 2/3$ the function $E_0\left[\Pi\left(a_H(1)(\widehat{s}),\,\widehat{s}\right)\right]$ has both an interior and a border local maximizer. However, note that:

$$s_3 \geq 1/2 \quad \Longleftrightarrow \quad \frac{v_L}{v_H} \geq \frac{(1-3q)}{3(1-q)} \equiv r_3(q), \tag{52}$$

$$r_1(q) - r_3(q) \propto 20q - 4 \geq 0 \;\; for \;\; all \;\; q \geq 1/5, \tag{53}$$

and

$$r_2(q) - r_3(q) \propto 15q^2 + 2q - 1 \geq 0 \;\; for \;\; all \;\; q \in [1/5; 2/3), \tag{54}$$

When $\frac{v_L}{v_H} \leq r_1(q)$ and, then, $\varphi(\widehat{s}) > 0$ for all $\widehat{s} \leq 1/2$, (52) implies that $s_M \geq 1/2$ if $\frac{v_L}{v_H} \geq r_3(q)$. (53) and (54) state that if $q \in [1/5; 2/3)$, then $\frac{v_L}{v_H} \in [r_2(q); r_1(q)]$ implies $\frac{v_L}{v_H} \geq r_3(q)$. Moreover, if $q \geq 1/3$, $r_3(q)$ is negative and, then, s_3 is larger than 1/2 for all v_L and v_H. By combining (52), (53) and (54) and by considering that when q is larger than 2/3, $\varphi(s_3)$ is lower than zero for all v_L and v_H, we can conclude that the global maximizer is $\widehat{s} = 1/2$ both when $q \in [1/5; 2/3)$ and $\frac{v_L}{v_H} \in [r_2(q); r_1(q)]$, and when $q \geq 2/3$. In the other cases, the global maximizer is $\widehat{s} = 1/2$ if $E_0 [\Pi (a_H(1)(1/2), 1/2)] > E_0 [\Pi (a_H(1)(s_M), s_M)]$ and $\widehat{s} = s_M$ otherwise.

Result 2: For all $\frac{v_L}{v_H} \leq r_2(q)$, *the optimal* $\widehat{s}$ *is the border maximizer* 1/2.

Result 3: For all $\frac{v_L}{v_H} \in (r_2(q); r_1(q))$, *the optimal* $\widehat{s}$ *is the border maximizer* 1/2 *if* $E_0 [\Pi (a_H(1)(1/2), 1/2)] > E_0 [\Pi (a_H(1)(s_M), s_M)]$ *and the interior maximizer* s_M *otherwise.* □

Proof of the accommodating equilibrium.

In the accommodating scenario, the investors problem $\mathcal{P}^A$ is to choose the levels of effort, a_L^A and a_H^A, and the contract, $C^A = \{w_0, w_L, w_H\}$, that maximize their expected profits (10), subject to the limited liability constraints and the incentive constraints, given $\lambda = 0$. From the binding limited liability constraints we obtain $w_0 = 0$. By combining (6) and $w_0 = 0$ we have (27). From (7), $w_0 = 0$ and $\lambda = 0$, we obtain:

$$q w_H + (1 - q) w_L = c \, a_H. \tag{55}$$

Substituting out $\lambda = 0$, $w_0 = 0$ and (55) in (10), we have:

$$\begin{aligned} E_0 [\Pi (a_H)] &= a_H [q (v_H - w_H) + (1 - q) (v_L - w_L)] \\ &= a_H [(q v_H + (1 - q) v_L) - c \, a_H] \end{aligned} \tag{56}$$

that does not depend on a_L. Indeed, in the accommodating scenario, the manager never recollects the bad signal, hence a_L is out of the equilibrium path. By deriving (56) with respect to a_H, we have the following necessary and sufficient condition:

$$\frac{\partial E_0 [\Pi (a_H)]}{\partial a_H} = (q v_H + (1 - q) v_L) - 2 \, c \, a_H = 0 \tag{57}$$

which gives:

$$a_H^A = \frac{(qv_H + (1-q)\, v_L)}{2c}. \tag{58}$$

Substituting out (58) in (55), we have:

$$qw_H^A + (1-q)w_L^A = \frac{(qv_H + (1-q)\, v_L)}{2}. \tag{59}$$

Hence, the accommodating equilibrium, perfect in the subgames, is characterized by any contract $C^A = \{0, w_L^A, w_H^A\}$, such that $qw_H^A + (1-q)w_L^A$ satisfies (59), and by the levels of effort a_H^A given by (58) and a_L^A given by (27).

Finally, since $a_H^A = a^P$ and $qw_H^A + (1-q)w_L^A = w^P$ (see (55) and (42)), the accommodating equilibrium is welfare equivalent to the pooling equilibrium. □

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