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Biased Supervision

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Abstract

When verifiable performance measures are imperfect, organizations often resort to subjective performance pay. This may give supervisors the power to direct employees towards tasks that mainly benefit the supervisor rather than the organization. We cast a principal-supervisor-agent model in a multitask setting, where the supervisor has an intrinsic preference towards specific tasks. We show that subjective performance pay based on evaluation by a biased supervisor has the same distorting effect on the agent's effort allocation as incentive pay based on an incongruent performance measure. If the principal can combine incongruent performance measures with biased supervision, the distortion in the agent's efforts is mitigated, but cannot always be eliminated. We apply our results to the choice between specialist and generalist middle managers, where a trade-off between expertise and bias may arise.

JEL codes: J24, M12, M52.

Keywords: subjective performance evaluation, middle managers, incentives, multitasking.

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1 Introduction

In many organizations, middle managers' assessment of employees' performance is an important determinant of bonus pay and career prospects.[1] If verifiable performance measures are imperfect, subjective performance evaluation may provide a more accurate assessment of employees' performance, thereby providing better incentives for employees to perform well. On the other hand, by its very nature, subjective performance evaluation can be manipulated, weakening the link between actual and reported performance. Furthermore, managers' role in determining employees' bonus pay and promotion opportunities gives them (more) power over their subordinates. Earlier work has shown that subjective performance pay based on middle managers' evaluations can be prone to favoritism (Prendergast and Topel 1996, Bol 2011, Dur and Tichem 2015), collusion (Tirole 1986, Thiele 2013), extortion (Laffont 1990, Vafaï 2002, 2010), and a lack of incentives or ability to monitor on the side of the manager (Gibbs et al. 2004, Bol 2011, Kamphorst and Swank 2012).

In this paper, we show that a supervisor can use the discretion inherent in subjective performance evaluation to pull agents towards tasks that benefit the supervisor more than the organization. We develop a principal-supervisor-agent model, where the agent exerts effort on multiple tasks. Efforts are not observable to the principal. The supervisor observes the agent's efforts with a probability that is increasing in the supervisor's ability. The supervisor provides a report on the agent's efforts to the principal, which can be used in determining the agent's (incentive) pay. Crucially, we assume that the supervisor has an intrinsic preference for particular tasks exerted by the agent. This makes that she overemphasizes these tasks when providing directions to the agent. Anticipating that not living up to the supervisor's expectations results in a bad evaluation, the agent works

[1] For instance, Eccles and Crane (1988), Gibbs (1995), and Bol (2011) document the use of subjective performance evaluation in (financial) service firms, Breuer et al. (2013) in a large call-center, Gibbs et al. (2004) in car-dealerships, Woods (2012) in an internal audit firm, and Medoff and Abraham (1980) in manufacturing firms.

towards the supervisor's goals. When the supervisor's preferences are not aligned with the principal's goals, this hurts the principal. As a consequence, akin to the standard multitasking model (Holmström and Milgrom 1991, Baker 1992, 2002), the principal optimally sets weaker subjective performance pay when the supervisor's preferences are less aligned, as well as when the supervisor has lower ability.[2]

This changes when the principal has access to an imperfect but verifiable performance measure. This measure can be ineffective, implying that it does not always provide a signal of performance, as well as incongruent. To structure ideas, consider one salesman of a local store owned by an electronics retail chain. The store's manager is an active member of the local community, so that she cares a lot about her store's reputation for providing good service. The salesman contributes to long-run store performance through sales effort and service effort. The latter does not contribute directly to short-run sales, but increases the reputation of the local store, which has long-run benefits to the retail chain. The store manager typically observes efforts, but the chain's headquarters only observes sales. If headquarters uses the salesman's sales figures to provide incentive pay, he will focus his efforts disproportionately on sales at the expense of service, leading to a sub-optimal outcome. Alternatively, headquarters could relate the salesman's pay to his performance evaluation as provided by the store manager. However, in evaluating performance, the store manager will put too much emphasis on service provision, thereby inducing the salesman to exert suboptimally low sales effort (from the perspective of headquarters). Combining verifiable sales figures with subjective performance evaluation in the salesman's bonus plan may bring several advantages. First, headquarters can use sales targets, which constrains the store manager in emphasizing service at the expense of sales. Second, the inclusion of subjective performance evaluation allows the store manager to pull the salesman away from the disproportionate focus on sales induced

[2] Supervisors can also use their power to affect (the behaviour of) employees in ways that are not directly linked to employees' tasks at work, e.g. by engaging in bullying, extortion, (sexual) harassment, etc. Our interest lies with supervisors' incentives to provide misaligned directions regarding employees' efforts at work.

by the verifiable sales measure. Third, the sales figures may give the store manager additional information on the salesman's efforts, which allows for better monitoring.[3]

We show that combining verifiable performance measurement and subjective performance evaluation mitigates the distortion that arises when using either type of performance measurement exclusively. This echoes findings in the multitasking literature on combining multiple incongruent performance measures (Feltham and Xie 1994, Datar et al. 2001, Budde 2007). This literature has shown that full congruence can be achieved if the number of verifiable measures meets or exceeds the number of tasks (although full congruence is not optimal if the measures differ in noisiness and agents are risk-averse). Even when all measures are biased towards the same task, congruence is possible by placing a negative weight on the most biased measure. In contrast, we show that this does not hold when some measures are subjectively determined, because placing a negative weight on the subjective evaluation is ineffective. The supervisor uses any discretionary power to put more emphasis on the tasks she considers undervalued in the objective performance measures. If a good evaluation has a positive (negative) effect on the agent's compensation, the supervisor threatens to provide a bad (good) evaluation unless the agent follows her directions. Hence, congruence is not feasible when the supervisor is even more biased than the verifiable performance measure.

The principal prefers the verifiable performance measure and the supervisor to have opposite biases compared to his relative valuation of tasks. We show that this allows the principal to implement non-distorted efforts, unless either the performance measure or the supervisor is relatively ineffective. If the probability that the performance measure provides a signal of the agent's efforts is too low, the supervisor ignores the performance target and induces her most preferred effort allocation. If the supervisor's ability is too low, the agent ignores her instructions and meets the performance target at lowest effort cost by working purely towards measured performance. In both situations, the principal

[3]For an example of an incentive plan that combines verifiable performance measures and subjective performance evaluation in a retail setting, see Bouwens and Kroos (2011).

optimally adjusts the performance target to allow for some bias in implemented efforts and reduces the strength of the agent's incentive pay.

The key novelty of our model is that the supervisor has intrinsic preferences over her subordinates' tasks, which may differ from the principal's relative valuation of these tasks. Such preferences could be driven by private benefits, by career concerns, or by professional norms. For instance, the supervisor may overemphasize providing inputs into her own work, thereby reducing her own workload. In a multi-unit organization, the supervisor could overemphasize tasks that benefit the supervisor's unit at the expense of activities that benefit other units. Alternatively, the supervisor may intrinsically consider particular tasks more important. Akerlof and Kranton (2005) suggest that internalization of norms is an important element of professional training (of e.g. physicians, scientists, and teachers). Professional norms may guide what is considered to be worthy of doing, and supervisors may impose these norms on their subordinates. Relatedly, Prendergast (2007) considers bureaucrats who care more or less for clients' well-being than the principal, possibly leading to over- or underprovision of services to clients.[4]

In our setup, a biased supervisor uses her discretionary power to direct employees towards activities that benefit her. Middle managers questioned by Guth and MacMillan (1986) stated that they sometimes make decisions that are not aligned with corporate strategy and goals, in order to protect their self-interest. Burgelman (1994) describes events at Intel in the 1980s, where middle managers made decisions on the allocation of R&D and manufacturing capacity that went against corporate strategy, eventually forcing senior management to change strategy.[5] Our analysis shows that misaligned

[4]The supervisor's bias in preferences over tasks differs from interpersonal preferences towards employees, such as altruism, spite or favouritism, as studied by e.g. Prendergast and Topel (1996), Giebe and Gürtler (2012), and Dur and Tichem (2015). These papers show that interpersonal preferences mute the incentive effect of subjective performance pay by weakening the link between agent's effort and pay.

[5]Rotemberg and Saloner (2000) provide a rationale for giving middle managers some discretion to go against corporate strategy. They argue that combining a visionary CEO, who champions some units or product lines over others, with more neutral middle management provides strong incentives to come up with investment projects for employees in the favoured units, while if they nonetheless fail to find

middle management may, but need not be detrimental for firm performance, depending on the available verifiable performance measures.

Most earlier work on combining subjective and objective performance measures considers subjective evaluation by the principal (Baker et al. 1994, Schmidt and Schnitzer 1995, Pearce and Stacchetti 1998, Budde 2007). Following Bull (1987), the emphasis lies on self-enforcing relational contracts, where the size of the subjectively determined bonus is restricted by the principal's incentive to give low evaluations despite good performance in order to save on bonus payments.[6] Thiele (2013) shows that in this setting delegation of subjective performance evaluation to a supervisor also entails low-powered incentives, in order to prevent collusion. Following Tirole (1986), collusion is also the main issue studied in static three-tier hierarchy models; for overviews see Laffont and Rochet (1997) and Mookherjee (2013). In this paper, we assume away the problem of collusion in our static model by assuming that side-contracts are not enforceable. Instead, we focus on the effects of supervisor bias on the interaction between subjective and objective performance evaluation.

Most related to our work are Laffont (1990) and Vafaï (2002, 2010), who study abuse of authority by the supervisor. In a setting with two agents and hard information on total output, Laffont (1990) shows that a supervisor can extort favors or side-payments from her subordinates by threatening to manipulate individual performance information. In response, the principal optimally reduces the weight on individual performance as reported by the supervisor in the agent's incentive pay, relative to the weight on total output. In Vafaï (2002, 2010), the supervisor may receive hard information about the agent's performance and can decide to conceal this information from the principal. Vafaï (2002) shows that the supervisor can collude with the agent when performance is bad, and can demand a bribe from the agent when performance is good. Preventing this

suitable projects, middle managers can allocate funds towards projects in other units.

[6]Suvorov and Van de Ven (2009) and Zabojnik (2014) show that the incentive to underreport is considerably smaller when the principal uses performance evaluation not only to promote effort, but also to provide the agent with information about his ability.

abuse of authority requires that the agent's pay is not higher after a report showing good performance compared to a report without performance information. This also prevents collusion, but leaves a rent to the agent. Vafaï (2010) extends the analysis to side-payments from the principal to the supervisor. In our setting, abuse of authority arises from the supervisor's soft information on agent's efforts and materializes in a distorted effort allocation. We analyze how the principal can use (imperfect) verifiable performance measures to constrain the supervisor's abuse of authority.[7]

We use our results to contribute to the debate on the relative merit of specialists and generalists in managerial positions. In the typical trade-off, specialists have higher ability on a particular task, but generalists have broader skills. Garicano (2000) argues that more able agents should be assigned to higher positions in the hierarchy in a one-dimensional task model, so that lower-level generalists can screen for tasks that can only be properly conducted by specialists. In contrast, Ferreira and Sah (2012) consider communication between layers and argue that generalists should be higher in the hierarchy to facilitate information transmission between lower-level units consisting of (different) specialists. Prasad (2009) argues that in a setting where tasks are complements, generalists are more likely to work on multiple tasks than specialists. He finds supporting evidence among non-academic researchers with doctoral degrees in the US, for whom the probability of getting management tasks is decreasing in past research success.

We argue that while specialists may have better monitoring ability, they are also more likely to have biased preferences (for instance arising from professional norms).[8] We show that in the absence of verifiable performance measures, this gives a trade-off between the strength of subjective performance incentives and the distortion induced in the agent's efforts. Hence, a generalist manager is preferred when a specialist's objectives are too

[7]In a setting where supervisors can conceal hard information, Kofman and Lawarree (1996) show that assigning a second supervisor makes it possible to prevent collusion.

[8]This corresponds to Li (2013), who studies the decisions by reviewers of grant proposals at the US National Institute of Health, and finds that reviewers are both biased towards projects in their own area as well as better able to infer the quality of proposals in their own area.

misaligned with the principal's, while a specialist is preferred when the generalist is too ineffective at supervision. The availability of a verifiable performance measure decreases both the cost of supervisor bias and the benefit of better monitoring. We find that the first effect typically outweighs the second effect, so that better verifiable performance measures increase the relative attractiveness of specialist supervisors.

The paper is organized as follows. The setup of the model is given in Section 2, after which we analyze benchmark cases in Section 3 and the full model in Section 4. We apply the results to the choice between specialists and generalists for managerial positions in Section 5. Section 6 concludes.

2 The model

We consider a principal-supervisor-agent model in which all players are risk neutral. The principal (P) employs one agent (A) and one supervisor (S). The outside option utility of both the agent and the supervisor is zero, and they are both protected by limited liability such that $w_A \geq 0$ and $w_S \geq 0$, where w_A (w_S) is the total wage payment to the agent (supervisor).

The agent works on two tasks $i \in \{1, 2\}$. The principal values the two tasks equally, and his utility is given by

$$U_P = e_1 + e_2 - w_A - w_S \tag{1}$$

where e_i is the agent's effort in task i. The agent's utility is given by:

$$U_A = w_A - \frac{1}{2}(e_1)^2 - \frac{1}{2}(e_2)^2 \tag{2}$$

The principal cannot observe the agent's efforts. However, there is a verifiable but imperfect performance measure of the agent's efforts. The measure is imperfect in two ways. First, the performance measure is biased towards one of the tasks. If the measure provides a signal, the level of measured performance m is given by

$$m\left(e_1, e_2\right) = \varphi e_1 + (1 - \varphi) e_2 \tag{3}$$

with $\varphi \in [0, 1]$. Hence, if $\varphi \neq \frac{1}{2}$, the relative importance of the two tasks in determining measured performance differs from the relative valuation of the tasks by the principal. Second, it is ex ante uncertain whether the performance measure will provide a signal about the agent's performance. The probability that this happens equals q, reflecting the reliability of the performance measure. Less-than-perfect reliability may stem from information system failures and other unforeseen events that invalidate measured performance. We denote the realization of the performance measure when it provides no signal by $m = \emptyset$. The principal can use this verifiable performance measure to provide the agent with performance-related pay, as will be discussed below.

The only role of the supervisor is to monitor the agent. Crucially, we assume that the supervisor cares about the tasks performed by the agent, possibly attaching different (relative) weights to the tasks as compared to the principal. As discussed in the Introduction, these preferences may stem from career concerns, professional norms, or intrinsic care for the tasks' output.[9] The supervisor's utility is given by:

$$U_S = w_S + \eta e_1 + (1 - \eta) e_2 \tag{4}$$

where $\eta \in [0, 1]$. Hence, the supervisor has biased preferences relative to the principal's valuation of tasks whenever $\eta \neq \frac{1}{2}$.[10] Our assumption of limited liability ($w_S \geq 0$) implies that the principal cannot acquire the rents from intrinsic utility obtained by the

[9] Schnedler (2008) studies the effects of differences in the marginal cost of effort for the agent, in a multitask setting with a risk-averse agent, a noisy verifiable performance measure, and no subjective performance evaluation. He shows that the performance measure is optimally biased towards the least-costly task. In our setting, allowing for intrinsic preferences over tasks on the side of the agent (leading to differences in the net marginal cost of effort) does not affect the results qualitatively.

[10] In our analysis, only the relative weights of the supervisor's preferences over tasks matters, not the absolute level. Hence, we could multiply the last two terms of (4) with the same parameter without affecting results.

supervisor. We make this assumption to ensure that the optimal contract as designed by the principal is aimed at optimizing the agent's incentives, rather than at increasing the supervisor's intrinsic utility. Note that the supervisor does not incur monitoring cost.

The supervisor observes the agent's actual effort choice with probability p, reflecting the supervisor's effectiveness in monitoring the agent. Whether the supervisor actually observes the agent's efforts is independent of whether the verifiable measure provides a signal. The supervisor's information is soft and cannot be made verifiable, but she can make a verifiable report r regarding her assessment of the agent's performance. It follows that the supervisor's report is cheap talk: she can provide any report independent of the agent's actual efforts.[11] When making her report, the supervisor has access to the signal provided by the verifiable performance measure.[12] The supervisor's report can provide a basis for (subjective) performance pay, as the principal can make the agent's pay dependent on the report r.

The discussion above implies that the agent's wage can depend on both measured performance m and the supervisor's report r. For expositional reasons we explicitly distinguish between purely objective performance pay $b(m)$ and subjective performance pay $c(m, r)$, such that the agent's wage equals $w_A(m, r) = b(m) + c(m, r)$.[13] The supervisor's wage can also be made dependent on both m and r. However, incentive pay based on the verifiable measure m would imply that the supervisor's relative preferences over tasks would be drawn closer to the relative weights on tasks in m. We argue in Section 4 that this is typically not in the principal's interest. Furthermore, incentive pay based on r would render the subjective performance evaluation useless, as discussed below. Hence,

[11] This differs from Tirole (1986) and Vafaï (2010), where the supervisor reports either the true (outcome of the agent's) efforts or reports that she received no information.

[12] Supervisors typically have access to the verifiable performance information when evaluating employees. For instance, Bol (2011) shows that the form supervisors had to fill out contained both verifiable and subjective items, where the items based on verifiable measures came with strict guidelines on how to translate performance into rating.

[13] On top of this, the principal may offer fixed wage a to the agent, so that $w_A = a + b(m) + c(m, r)$. However, our assumption of limited liability ($w_A \geq 0$) makes that the principal always sets $a = 0$. It also implies that the agent's participation constraint is always fulfilled.

the principal offers a fixed wage $w_S = 0$, which is accepted by the supervisor.

Provided that the agent's wage depends on the supervisor's evaluation, the supervisor can make demands to the agent. We assume that side-contracts are too costly to enforce (both between the supervisor and the agent as well as between the supervisor and the principal).[14] Instead, the supervisor and the agent engage in an implicit agreement. Given that the supervisor's evaluation is cheap talk, her demands have most influence when she promises to provide evaluations such that her report has a maximal effect on the agent's wage. Without loss of generality, we assume that the supervisor demands effort levels $\underline{e_1}$ and $\underline{e_2}$, and promises to provide in return the report that yields the highest wage (given measured performance m). If the supervisor learns that the agent did not adhere to the demand, she provides the report that yields the lowest possible wage. Effectively, this implies that the supervisor will provide one of two reports. Hence, we can reduce the set of possible reports to two, $r \in \{r_G, r_B\}$. Note that the difference in bonus pay following a good subjective evaluation r_G and a bad subjective evaluation r_B may depend on measured performance m.

Given that the supervisor is not residual claimant and, hence, does not bear the cost of the agent's bonus pay, she is ex post indifferent between providing a good evaluation and bad evaluation. We assume that after observing the agent's effort and measured performance m, the supervisor adheres to the implicit agreement. In a repeated game, adhering to the implicit agreement would be strictly preferred by the supervisor, to maintain credibility.

Lastly, we make the assumption that if the verifiable performance measure provides no signal ($m = \emptyset$, which happens with probability $1 - q$), the agent receives the highest

[14]This makes collusion non-sustainable. The bonus is paid to the agent after the supervisor has reported to the principal, implying that the agent has no incentive to transfer part of the bonus to the supervisor. Collusion is studied by e.g. Tirole (1986) and Thiele (2013). Allowing for side-contracts in our model renders subjective performance evaluation useless, as we discuss in Section 3.3.

possible wage, possibly conditional on the supervisor's report:

$$w_A(\emptyset, r) = \max_m w_A(m, r) \tag{5}$$

In other words, the agent receives the maximal bonus given the supervisor's report, unless the principal can prove that the agent is not entitled to this bonus. This assumption makes that an unreliable performance measure is actually costly to the principal, as providing incentives yields a rent to the agent (given the agent's limited liability). In a similar vein, we assume that if the supervisor learns nothing about the agent's efforts, she provides the report that yields the highest subjectively determined bonus (given measured performance m), again implying that ineffective supervision yields rents to the agent.[15] These assumptions allow us to study the trade-off between supervisor effectiveness and bias as well as the interaction between imperfect objective and subjective performance measurement and incentive provision in a tractable way.

The timing of the game is as follows:

1. The principal offers the agent a contract, determining $w_A(m, r)$.
2. The agent accepts or rejects the contract. If the agent rejects, all players receive their outside option payoff.
3. The supervisor demands effort levels $\{\underline{e_1}, \underline{e_2}\}$ from the agent.
4. The agent chooses effort, which is observed by the supervisor with probability p. Measured performance m is generated with probability q.
5. The supervisor sends her report $r \in \{r_G, r_B\}$.
6. Payoffs are realized.

[15] Alternatively, the agent could receive a bonus only when performance is both objectively measured and observed by the supervisor. The agent would be compensated for the low probability of receiving a bonus by high bonus levels. In our setup (in particular given our assumptions of risk-neutrality and limited liability), this would bring higher payoffs to the principal, as an unreliable performance measure and ineffective supervision would not lead to rents for the agent.

We use backward induction to solve for a sub-game perfect Nash equilibrium.

3 Benchmarks

3.1 Complete information

Suppose the principal can contract on effort directly. Neither the supervisor nor the performance measure have any use in this case. The principal demands the effort levels that maximize his utility (1) subject to the agent's participation constraint $U_A \geq 0$, where U_A is given by (2). Ignoring the supervisor's intrinsic utility, this gives first-best levels of effort $e_1 = e_2 = 1$. The participation constraint of the agent is satisfied by setting $w_A = 1$ if and only if $e_1 = e_2 = 1$ and $w_A = 0$ otherwise. This results in $U_P = 1$ and $U_A = 0$. Hence, in the absence of moral hazard problems, the principal optimally induces the agent to balance effort levels across tasks.

3.2 Pure objective performance pay

In the absence of subjective performance evaluation, the model is a standard multitasking model. Without loss of generality, we assume that the principal offers the agent a fixed bonus b if measured performance (3) is above a specified target, $m \geq \underline{m}$, and no bonus if $m < \underline{m}$. The agent derives no benefits from outperforming the principal's target $\underline{m}$. Hence, in meeting the principal's target, the agent maximizes (2) subject to $m(e_1, e_2) = \underline{m}$. This gives

$$e_1 = \frac{\varphi}{\varphi^2 + (1-\varphi)^2}\underline{m} \tag{6}$$

$$e_2 = \frac{1-\varphi}{\varphi^2 + (1-\varphi)^2}\underline{m} \tag{7}$$

It follows that $e_1 = e_2$ only when $\varphi = \frac{1}{2}$. If $\varphi \neq \frac{1}{2}$, the agent provides more effort on the task that impacts measured performance m most. Given that the agent satisfies $m = \underline{m}$, he optimally chooses an effort combination such that

$$\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi} \tag{PMR}$$

which we refer to as the Performance Measure's Ratio (PMR).

If the agent decides not to meet the performance target $\underline{m}$, he only receives bonus b if the performance measure provides no signal, which happens with probability $1-q$. As this probability is independent of effort, optimal effort is zero. Hence, the agent chooses to meet the performance target if

$$b - \frac{1}{2}\frac{1}{\varphi^2+(1-\varphi)^2}\underline{m}^2 \geq (1-q)b \tag{8}$$

which shows that the agent's rents $(1-q)b$ are decreasing in the effectiveness of the performance measure q.

The principal chooses b and $\underline{m}$ to maximize his utility (1) subject to the agent's incentive compatibility constraint (8), which yields the following solution:

$$b = \frac{1}{2}\frac{q}{\varphi^2+(1-\varphi)^2} \tag{9}$$

$$\underline{m} = q \tag{10}$$

Regardless of the bias of the performance measure the principal demands $\underline{m} = q$. The principal demands lower total effort when the performance measure is more biased.[16] This is reflected in the bonus paid to the agent, which is higher when the performance measure is more aligned with the principal's objective. Equilibrium payoffs are given by

$$U_A = \frac{1}{2}\frac{q\,(1-q)}{\varphi^2+(1-\varphi)^2} \tag{11}$$

$$U_P = \frac{1}{2}\frac{q}{\varphi^2+(1-\varphi)^2} \tag{12}$$

[16] Using (6) and (7), it is easily seen that the sum of efforts e_1+e_2 is decreasing in $|\frac{1}{2}-\varphi|$.

The principal benefits from having a more effective and better aligned performance measure, as U_P increases in q and decreases in $|\frac{1}{2} - \varphi|$. Note that the agent's rent increases as the alignment of the measure and the principal's valuation of tasks improves. It is optimal for the principal to induce more effort the more aligned the measure, despite the higher rents to the agent. For a given φ, the sum of U_A and U_P is maximal when $q = 1$, reflecting that the principal sacrifices surplus to reduce the agent's rent when $q < 1$.

3.3 Pure subjective performance pay

Without objective performance measures, incentive pay is solely based on the supervisor's subjective report r. In the implicit agreement between the supervisor and the agent, the supervisor promises to provide a positive report to the principal if the agent performs at least effort levels $\underline{e_1}$ and $\underline{e_2}$. The agent follows the supervisor's demands when a good report yields a sufficiently higher bonus than a bad report. Given limited liability, the optimal incentive scheme has wage zero after a bad report, $c(r_B) = 0$. Below, we denote $c(r_G) = c$.

The least costly way for the agent to satisfy the supervisor's demands is to provide exactly the demanded effort levels. If the agent decides to exert lower effort levels, he only receives the bonus when the supervisor does not observe the agent's efforts, which happens with probability $1 - p$. In this case, the best alternative is to provide no effort at all. Hence, the supervisor sets $\underline{e_1}$ and $\underline{e_2}$ to maximize her utility (4), subject to the agent's incentive compatibility constraint:

$$c - \frac{1}{2}\underline{e_1}^2 - \frac{1}{2}\underline{e_2}^2 \geq (1 - p)\, c \tag{13}$$

In order to induce the agent to exert effort, the agent must be given a rent equal to $(1 - p)\, c$. This follows from the fact that the supervisor does not always observe whether the agent performs as desired, so that shirking by the agent could pass undetected. The incentive compatibility constraint binds as the supervisor values additional effort. The supervisor's optimal effort demands are given by:

$$\underline{e_1} = \eta\sqrt{\frac{2pc}{\eta^2 + (1-\eta)^2}} \tag{14}$$

$$\underline{e_2} = (1-\eta)\sqrt{\frac{2pc}{\eta^2 + (1-\eta)^2}} \tag{15}$$

It follows that $\underline{e_1}$ and $\underline{e_2}$ are increasing in bonus c and in the supervisor's effectiveness p. Both allow the supervisor to make stronger demands. Furthermore, the supervisor induces the agent to focus disproportionately on her preferred task, demanding effort levels such that:

$$\frac{e_2}{e_1} = \frac{1-\eta}{\eta} \tag{SR}$$

which we will refer to as the Supervisor's (preferred effort) Ratio (SR).

It follows from (14) and (15) that for given c and p, the principal's valuation of implemented efforts, $e_1 + e_2$, is higher when the supervisor's preferences are more aligned with the principal, i.e. when η is closer to $\frac{1}{2}$. Hence, a more aligned supervisor induces higher total effort for a given bonus, which benefits the principal.

The principal chooses c to maximize utility (1), taking into account the supervisor's effort demands (14) and (15). The optimal subjective bonus is given by:

$$c = \frac{1}{2}\frac{p}{\eta^2 + (1-\eta)^2} \tag{16}$$

The bonus is increasing in p, as more effective supervisors leave less rents to the agent. The bonus also increases in the alignment between the supervisor and the principal, as more aligned supervisors use their discretionary power to demand higher total effort.

Equilibrium effort levels are given by:

$$e_1 = \frac{\eta p}{\eta^2 + (1-\eta)^2} \tag{17}$$

$$e_2 = \frac{(1-\eta)\, p}{\eta^2 + (1-\eta)^2} \tag{18}$$

Hence, if $p \neq 1$ and/or $\eta \neq \frac{1}{2}$, effort provision under subjective pay for performance is below first-best levels.

The agent's and principal's equilibrium payoffs are given by:[17]

$$U_A = \frac{1}{2}\frac{p\,(1-p)}{\eta^2 + (1-\eta)^2} \tag{19}$$

$$U_P = \frac{1}{2}\frac{p}{\eta^2 + (1-\eta)^2} \tag{20}$$

Note that the payoffs of the agent and the principal are identical to their payoffs when using pure objective pay for performance (see (11) and (12)), with $p = q$ and $\eta = \varphi$ (or $\eta = 1 - \varphi$). The principal responds to biased supervision by reducing subjective performance pay, as in case of incentive pay based on the incongruent verifiable performance measure. Hence, biased supervision is as harmful for the principal (and the agent) as incongruent performance measures.[18]

It is now easily explained why we (must) abstract from side-contracting between the supervisor on the one hand and the principal or the agent on the other hand. As subjective performance evaluation is cheap talk and the supervisor is ex post indifferent

[17] The supervisor's utility equals $U_S = p$ and, hence, is independent of her preferences over tasks. The higher utility attained by a more biased supervisor for a given bonus c is exactly offset by the reduction in the bonus by the principal. The supervisor's limited liability constraint makes that her utility is irrelevant to the principal. Without limited liability, the principal would distort the bonus in order to increase the supervisor's intrinsic utility, which he would capture through a negative base wage.

[18] If the supervisor's bias is private information, such that the principal only knows the distribution of η but not the current supervisor's bias, a similar result obtains. From effort levels (17) and (18), it follows that given bonus c, the principal's payoff is decreasing and convex in supervisor bias $|\frac{1}{2} - \eta|$. Hence, for any distribution of bias $|\frac{1}{2} - \eta|$, the principal optimally sets a bonus below the optimal bonus in case of a supervisor with average bias. Hence, uncertainty about supervisor bias leads to (even) weaker subjective performance pay.

between reports r_G and r_B, a contractual agreement between the supervisor and the agent (principal) to provide a positive (negative) report in return for payment would make the performance evaluation independent of the agent's effort. Hence, (anticipation of) such contracts would eliminate any benefits of subjective performance pay. In practice, subjective performance pay may lead to collusive behaviour in some organizations. However, the pervasive use of subjective performance evaluation suggests that in many organizations the possibility of collusion does not outweigh the (perceived) benefits of subjective performance evaluation.

3.4 Pure subjective versus pure objective pay for performance

Comparing equilibrium effort levels under pure objective performance pay, as given by (6) and (7) with $\underline{m} = q$, and subjective pay for performance, as given by (17) and (18), shows that objective performance pay yields the same outcome as subjective performance pay if $p = q$ and $\eta = \varphi$ or $\eta = 1 - \varphi$. Then, both means of incentivizing the agent yield the same distortion in efforts and have the same quality of monitoring.

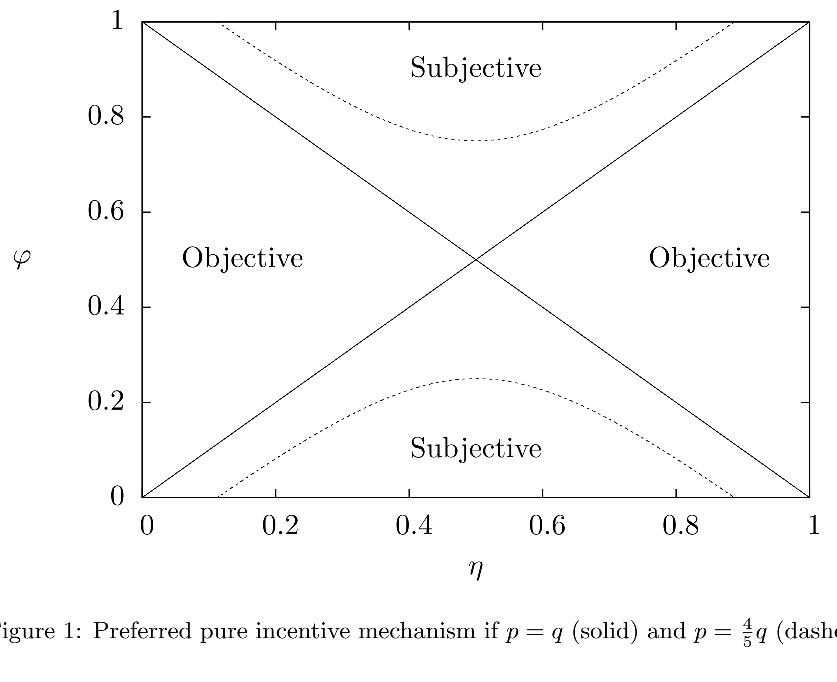

Figure 1: Preferred pure incentive mechanism if $p = q$ (solid) and $p = \frac{4}{5}q$ (dashed).

More generally, suppose that the principal must choose between implementing either objective or subjective performance pay. Comparing the principal's payoffs (12) and (20) shows that the principal is better off using discretionary performance pay when:

$$\frac{p}{q} > \frac{\eta^2 + (1-\eta)^2}{\varphi^2 + (1-\varphi)^2} \tag{21}$$

Even if the supervisor is more biased than the performance measure (e.g. when $\frac{1}{2} < \varphi < \eta$), subjective performance pay is still preferred when the supervisor is sufficiently more effective than the performance measure, and vice versa. As the right-hand side of (21) can only take values between $\frac{1}{2}$ and 2, it follows that subjective performance pay is always preferred to objective performance pay when $p > 2q$, whereas subjective performance pay is always preferred if $q > 2p$. Figure 1 gives the preferred type of performance pay for given values of η, φ, p, and q.[19]

4 Subjective and objective performance pay combined

Now consider the case where both objective and subjective performance measures are available. This has several implications. First, the supervisor can pull the agent away from following the bias inherent in the objective performance measure. Intuitively, she will pull the agent closer to her own optimal effort ratio. Second, the principal may be able to use the objective performance measure to constrain the supervisor. Third, objectively measured performance gives the supervisor additional information on the agent's effort. This reduces the agent's opportunities to shirk and, hence, his rents.

We first establish several general features of the optimal contract.

Lemma 1 *The optimal contract is a forcing contract, where the agent receives compensation unless either objectively measured performance m differs from a pre-determined target $\underline{m}$ or the supervisor reports bad performance r_B.*

[19] It is also possible to interpret Figure 1 as a comparison between supervisors who differ in bias and effectiveness.

Proof. The proof is given in the Appendix. ■

To understand Lemma 1, consider first a supervisor with the same bias as the objective performance measure, $\eta = \varphi$. The use of objective performance pay leads to an outcome where $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$, as this effort ratio allows the agent to reach a given level of measured performance m at minimal effort cost (see (PMR)). Adding subjective performance pay does not affect this bias, as the supervisor also prefers to induce this effort ratio (given $\eta = \varphi$, see (SR)). There is still a benefit to the principal of conditioning the agent's pay on both objectively measured performance and subjective performance evaluation, as it yields the highest probability of detecting a shirking agent. The forcing contract minimizes the agent's rents. This benefit of combining objective and subjective performance evaluation carries over when the supervisor's preferences differ from the bias in the objective performance measure, i.e. when $\eta \neq \varphi$. Then, the supervisor uses any subjectively determined bonus to pull the agent towards her own preferred effort ratio. By conditioning the payout of the subjective bonus on objectively measured performance, the principal also constrains the supervisor. Denying the agent the bonus despite a positive report if measured performance does not meet a pre-determined target $\underline{m}$ reduces the supervisor's power to demand efforts that fall short of the target.

A direct implication of Lemma 1 is that there is no clear separation between objective and subjective performance pay. Optimally, the agent's compensation depends on both objectively measured performance as well as the supervisor's subjectively determined report. For instance, the contract could have verifiable performance pay $b(m \neq \underline{m}) = 0$ and $b(\underline{m}) > 0$, with the 'disqualifier' that the bonus is forfeit after a bad subjective evaluation: $c(m, r_B) = -b(m)$ and $c(m, r_G) = 0$ for all m. Alternatively, the contract could have subjective performance pay $c(m, r_B) = 0$ and $c(m, r_G) > 0$, coupled with $b(m = \underline{m}) = 0$ and $b(m \neq \underline{m}) = -c(m, r)$ for all m and r.[20] Given that the agent receives the same bonus for meeting both the performance target and the supervisor's request,

[20]Note that for both types of contract, the agent's limited liability constraint implies that total compensation can never be negative.

both contracts provide the same incentives at equal cost. In the analysis below, we use the latter type of contract, which is without loss of generality. For ease of notation, below we denote $c(m, r_G) = c$.

Before deriving the optimal contract, we first establish that not all possible effort allocations can be implemented through the combination of objective and subjective performance pay.

Lemma 2 *If $\eta > \varphi$ ($\eta < \varphi$), effort allocations such that $\frac{e_2}{e_1} > \frac{1-\varphi}{\varphi}$ ($\frac{e_2}{e_1} < \frac{1-\varphi}{\varphi}$) cannot be implemented.*

Proof. In this proof, we focus on the case where $\eta > \varphi$. The case $\eta < \varphi$ is the mirror image. Consider any combination of (subjective) performance pay c and performance target $\underline{m}$ by the principal, and requested efforts $\underline{e_1}$ and $\underline{e_2}$ by the supervisor, such that the agent receives the bonus unless $r = r_B$ or $m \neq \underline{m}$. Several outcomes are possible. First, the agent can ignore both the principal's target and the supervisor's request. Then, optimal effort is zero. Second, if the agent ignores the supervisor's request but adheres to the principal's target $m = \underline{m}$, the agent's optimal effort allocation has $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$ (see (PMR)). Third, the supervisor can ignore the principal's target and induce the agent to follow her request. When ignoring the target, the supervisor's optimal effort allocation is such that $\frac{e_2}{e_1} = \frac{1-\eta}{\eta} < \frac{1-\varphi}{\varphi}$ (see (SR)), where the inequality sign follows from $\eta > \varphi$. Lastly, the agent can follow the supervisor's request while the supervisor adheres to the principal's target. In the latter situation, the supervisor's demands must meet the agent's incentive compatibility constraint. Using the agent's utility function (2), this constraint is given by:

$$c - \frac{1}{2}\underline{e_1}^2 - \frac{1}{2}\underline{e_2}^2 \geq \max\left\{(1-p)(1-q)c, (1-p)c - \frac{1}{2}\frac{1}{\varphi^2 + (1-\varphi)^2}\underline{m}^2\right\} \tag{22}$$

The first term in braces is the agent's expected utility when exerting no effort at all. The second term in braces is the agent's expected utility when reaching $m = \underline{m}$ at lowest effort cost as given by effort levels (6) and (7), i.e. by choosing the performance measure effort ratio (PMR). It follows that if the agent can be induced to exert any effort allocation on $m = \underline{m}$, an effort allocation such that $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$ is also feasible. A straightforward extension of the analysis in Section 3.2 yields that the principal can implement effort allocations satisfying $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$ by setting $c = \frac{1}{2}\frac{(p+(1-p)q)\underline{m}^2}{\varphi^2+(1-\varphi)^2}$. Keeping $\underline{m}$ constant, an increase in c makes different effort allocations on $m = \underline{m}$ feasible. As $\eta > \varphi$, the supervisor prefers effort allocations on $m = \underline{m}$ with more e_1 over effort allocations with less e_1. Hence, the supervisor optimally requests an effort allocation on $\underline{m}$ such that $\frac{e_2}{e_1} \leq \frac{1-\varphi}{\varphi}$. Summarizing, none of these outcomes has $\frac{e_2}{e_1} > \frac{1-\varphi}{\varphi}$. ■

Lemma 2 is illustrated by Figure 2, for the case where $\eta > \varphi$. The figure depicts the $m = \underline{m}$ performance target which runs orthogonal to the line representing the performance measure's effort ratio (PMR), as well as the set of points where the agent's incentive compatibility constraint (ICC) given by (22) is binding. The supervisor can only implement effort allocations on the $m = \underline{m}$ line below the ICC, as indicated by the thicker line segment. This line segment always includes the effort ratio on the line (PMR), as this is the effort ratio that yields $m = \underline{m}$ at minimal effort cost. The supervisor's indifference lines run orthogonal to the line representing the supervisor's preferred effort ratio (SR). If $\eta > \varphi$, these indifference lines are steeper than the $m = \underline{m}$ line. Hence, the supervisor prefers to implement an effort allocation given by the intersection between the $m = \underline{m}$ line and the ICC with the highest e_1. This implies that the principal cannot induce the supervisor to request an effort allocation that lies beyond line (PMR) from the supervisor's perspective, as given $m = \underline{m}$ and $\eta > \varphi$ the supervisor always prefers an effort ratio $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$ over effort ratio's such that $\frac{e_2}{e_1} > \frac{1-\varphi}{\varphi}$. Similarly, if $\eta < \varphi$, the supervisor always prefers to induce effort ratio $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$ over effort ratio's such that $\frac{e_2}{e_1} < \frac{1-\varphi}{\varphi}$.

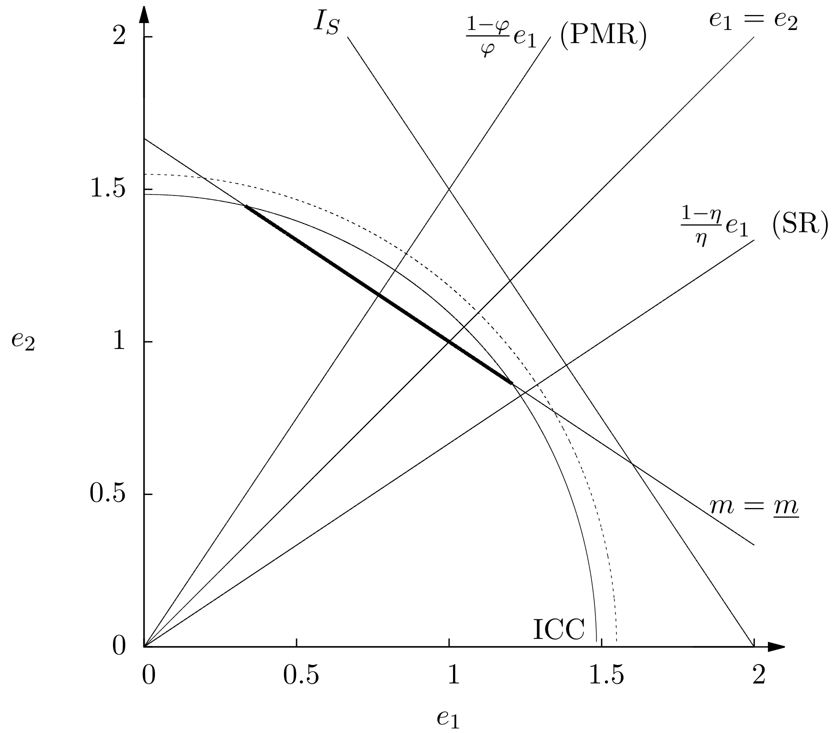

Figure 2: An example with $\eta = \frac{3}{5}$ and $\varphi = \frac{2}{5}$. The feasible set of demands for the supervisor is given by the bold chord, which is always centered around (PMR). Lowering $\underline{m}$ or raising the ICC can lengthen this chord.

Lemma 2 underlines an important difference between objective and subjective performance evaluation. If the supervisor would be a second verifiable performance measure with bias $\eta \neq \varphi$, any effort allocation would have been feasible, as shown by Datar et al (2001). This holds even when the two measures are biased in the same direction. By punishing too high performance on the most biased measure combined with rewarding high performance on the least-biased measure, the agent could be induced to choose effort allocations that are less biased than the least-biased performance measure. Here, however, the supervisor can use her discretionary power to make the agent choose an effort allocation closer to her optimal ratio, as she subjectively determines whether the agent's performance is good or bad. Hence, if the supervisor is more biased than the verifiable performance measure ($\eta > \varphi > \frac{1}{2}$ or $\frac{1}{2} > \varphi > \eta$), the supervisor uses any leeway to increase the distortion in efforts. It follows that in this situation, the least-biased effort ratio that can be implemented is given by the performance measure's effort ratio (PMR), $\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$.

It is possible to implement effort allocations beyond the supervisor's preferred effort ratio (SR), i.e. to implement $\frac{e_2}{e_1} < \frac{1-\eta}{\eta}$ when $\eta > \varphi$ and vice versa, although it requires commitment to penalize too high verifiable performance. This can be easily inferred from Figure 2: by raising c, the ICC can be shifted up such that the intersection between the $m = \underline{m}$ line and the agent's ICC lies to the right of the line representing the supervisor's preferred effort ratio (SR). Then, the supervisor would prefer to request the effort allocation given by the intersection of the ICC with (SR). However, this would generate measured performance $m > \underline{m}$, implying that with probability q the principal would not pay out the bonus even when the agent would follow the supervisor's request. Anticipating this, the agent would not accept the supervisor's request, given that q is sufficiently high q. The best feasible effort allocation for the supervisor is again where the ICC intersects the $m = \underline{m}$ line with highest e_1, which implies that $\frac{e_2}{e_1} < \frac{1-\eta}{\eta}$.

Figure 2 also helps to build intuition for the results that follow. A precise performance measure (high q) allows the principal to enforce a particular level of objectively measured performance m at low cost. This restricts the supervisor, who cannot simply implement an effort allocation with her most-preferred effort ratio (SR), as was possible in the absence of the verifiable performance measure (Section 3.3). Yet, the performance measure also helps imperfect supervisors by increasing the chance that a shirking agent is caught. This allows supervisors to request higher effort levels for a given discretionary bonus c.

If monitoring or performance measurement is sufficiently imperfect, two additional constraints arise. First, if the supervisor's effectiveness is sufficiently low, it becomes attractive for the agent to only pretend to abide by the supervisor's request. Instead, the agent could obtain the same level of measured performance $m = m(\underline{e_1}, \underline{e_2})$ at lower cost by choosing efforts along the performance measure's effort ratio (PMR). Second, if the performance measure is sufficiently imprecise, the supervisor is tempted to ignore the principal's target $m = \underline{m}$ and request effort levels along her preferred effort ratio (SR). The optimal contract depends on whether these constraints are binding.

Propositions 1 to 4 below give the optimal contract, differentiated by whether or not these constraints are binding. We focus on the case where $\eta > \varphi$, the case of $\eta < \varphi$ is the mirror image.

Proposition 1 *Given $\eta > \varphi$, the optimal contract induces balanced effort $e_1 = e_2$ if and only if (i) $\varphi \leq \frac{1}{2}$ and (ii) $\frac{1}{(1-2\eta)^2}\frac{q}{(1-q)} \geq p \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$.*
Under these conditions, the optimal contract has $c = \underline{m} = (p + (1-p)\,q)$, $b(m = \underline{m}) = 0$, and $b(m \neq \underline{m}) = -c$.
The equilibrium effort levels are $e_1 = e_2 = (p + (1-p)\,q)$.

Proof. The proof is given in the Appendix. ■

Proposition 1 gives the necessary and sufficient conditions under which the principal can induce balanced efforts. The outcome is as if the principal has access to an unbiased performance measure that is as effective as the supervisor and the verifiable measure combined. Condition (i) follows from Lemma 2: the principal cannot induce the supervisor to implement balanced efforts when the supervisor is more biased than the verifiable performance measure. Condition (ii) implies that the effectiveness of the supervisor and the performance measure should not be too different. If the supervisor's effectiveness p is too low, the agent is tempted to feign satisfying the supervisor's demands by generating $m = m(\underline{e_1}, \underline{e_2})$ at lower cost along the PMR. The supervisor cannot use the objective performance measure to detect this breach of the implicit agreement. This is more attractive to the agent when the effectiveness of the performance measure (supervisor) is larger (smaller). The benefits of this deviation for the agent are larger when the performance measure is more biased. In contrast, if the performance measure is relatively ineffective, the supervisor may have an incentive to ignore the performance target $\underline{m}$. A less effective objective performance measure makes it less likely that the principal detects such a deviation, which increases the incentive of the agent to follow the supervisor in deviating. Deviating is more beneficial for more biased supervisors.

The following Propositions describe the optimal outcomes when the conditions in Proposition 1 are not met. Proposition 2 considers the case where $\varphi > \frac{1}{2}$, while Propositions 3 and 4 consider the cases where p and q are too different.

Proposition 2 *Given $\eta > \varphi > \frac{1}{2}$, the principal optimally induces efforts along the PMR ($\frac{e_2}{e_1} = \frac{1-\varphi}{\varphi}$), if and only if $p \leq \frac{q}{(1-q)} \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}$.*
Under these conditions, the optimal contract has $c = \frac{(p+(1-p)q)}{2\left(\varphi^2+(1-\varphi)^2\right)}$, $\underline{m} = (p + (1-p)\, q)$, $b(m = \underline{m}) = 0$, and $b(m \neq \underline{m}) = -c$.
The equilibrium effort levels are $e_1 = (p + (1-p)\, q) \frac{\varphi}{\left(\varphi^2+(1-\varphi)^2\right)}$ and $e_2 = (p + (1-p)\, q) \frac{1-\varphi}{\left(\varphi^2+(1-\varphi)^2\right)}$.

Proof. The proof is given in the Appendix. ■

Figure 3 gives an example of this situation. Given $\eta > \varphi > \frac{1}{2}$, the supervisor uses any available room to move away from the PMR to distort the agent's efforts even further away from the principal's objectives. Hence, it is optimal for the principal to constrain the supervisor to the PMR. Compared to the case where $\varphi \leq \frac{1}{2}$, the principal demands the same measured performance $\underline{m}$, but sets a smaller bonus. Thereby, the principal makes it impossible for the supervisor to request effort levels that are more biased than the verifiable performance measure. Even though this implies that the supervisor does not mitigate the bias inherent in the objective performance measure, she still adds value for the principal. The supervisor provides additional monitoring, which allows for a reduction in the rents left to the agent. The resulting outcome is as if the principal has access to a biased performance measure as effective as the supervisor and the verifiable measure combined. The only constraint on the outcome is that the supervisor should not be tempted to ignore the target. As before, this happens when the verifiable measure is sufficiently imprecise relative to the effectiveness of the supervisor, and is more likely when the PMR and the SR are more apart.[21]

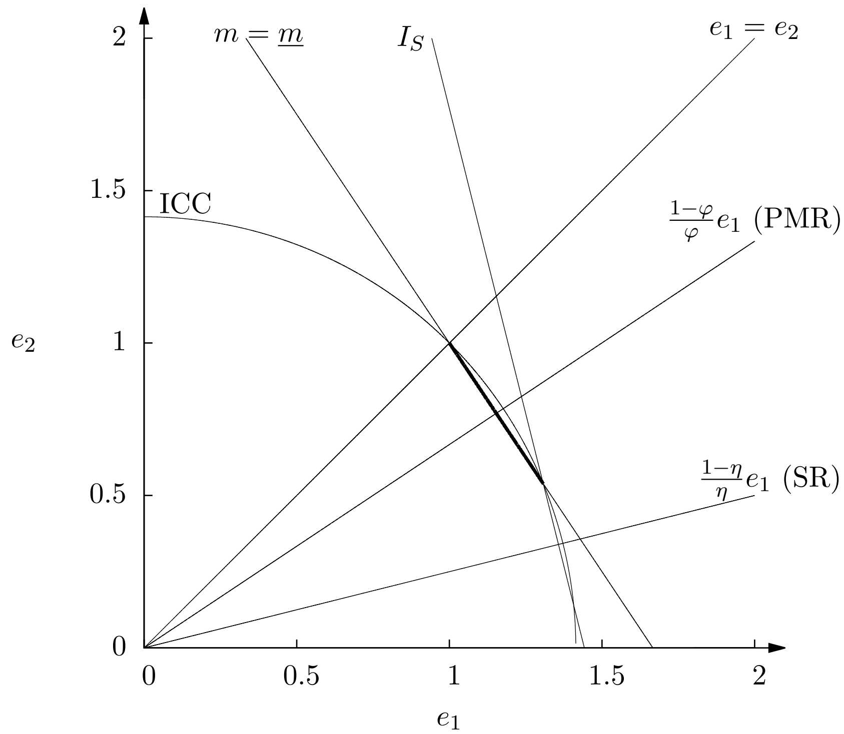

Figure 3: An example with $\eta = \frac{4}{5}$ and $\varphi = \frac{3}{5}$. The feasible set of demands for the supervisor is given by the bold chord, which is always centered around (PMR). Even though balanced efforts are feasible here the supervisor prefers to induce highly distorted efforts. Hence, the principal is better off raising $\underline{m}$ to the intersection between (PMR)and the ICC.

Combining Propositions 1 and 2, it follows that if p and q are sufficiently large, the supervisor's bias only affects whether balanced efforts can be implemented. Other than that, neither the optimal contract nor equilibrium efforts depend on the bias of the supervisor. The following proposition describes the optimal contract when the supervisor is (relatively) ineffective.

Proposition 3 *Suppose $\eta > \varphi$ and $\varphi \leq \frac{1}{2}$. If $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, the optimal contract induces unbalanced efforts biased towards the PMR, $\frac{e_2}{e_1} > 1$.*

[21] As the contract in Proposition 2 implements effort levels that meet the principal's performance target $\underline{m}$ at minimal effort costs, the agent never benefits from choosing different effort levels while still generating measured performance $\underline{m}$.

Under these conditions, the optimal contract has $c = \frac{\left(\sqrt{(1-p)q}+(1-2\varphi)\sqrt{p}\right)^2}{2\left(\varphi^2+(1-\varphi)^2\right)}$, $\underline{m} = (1-p)q + (1-2\varphi)\sqrt{p(1-p)q}$, $b(m=\underline{m}) = 0$, *and* $b(m \neq \underline{m}) = -c$.
The equilibrium effort levels are $e_1 = \frac{\left(\sqrt{(1-p)q}+(1-2\varphi)\sqrt{p}\right)}{\varphi^2+(1-\varphi)^2}\left(\varphi\sqrt{(1-p)q} + (1-\varphi)\sqrt{p}\right)$ *and* $e_2 = \frac{\left(\sqrt{(1-p)q}+(1-2\varphi)\sqrt{p}\right)}{\varphi^2+(1-\varphi)^2}\left((1-\varphi)\sqrt{(1-p)q} - \varphi\sqrt{p}\right)$.

Proof. The proof is given in the Appendix. ■

If the supervisor is ineffective, the agent is tempted to feign compliance by meeting the performance target $m = \underline{m}$ at minimal effort cost rather than by following the supervisor's request. The optimal deviation would be to choose the effort ratio equal to the performance measure's ratio as given by (PMR). Feigning compliance is particularly attractive for the agent when the performance measure is both highly effective and highly biased while the supervisor is weak. Anticipating the agent's incentive to deviate, the supervisor is forced to shift her requested effort levels closer to the PMR. This increases the agent's rents, as can be seen from Figure 2.

The principal optimally responds to this inefficiency in two ways. First, he sets a higher performance target $\underline{m}$ as compared to the case with a more effective supervisor. While this forces the supervisor to request a biased effort ratio closer to the PMR, it also reduces the agent's rents when feigning compliance, which makes following the supervisor's request relatively more attractive. Second, as the implemented effort levels remain biased toward the PMR, the principal lowers the bonus. Hence, compared to the case with a more effective supervisor (Proposition 1), the bonus is smaller while the performance target is higher.

The imbalance in the effort levels is decreasing in supervisor effectiveness p and increasing in the bias of the verifiable performance measure $|\frac{1}{2} - \varphi|$.[22] Provided that the supervisor is not more biased than the verifiable performance measure ($\eta > \varphi$ and $\varphi \leq \frac{1}{2}$), the supervisor's bias is irrelevant. For the principal, this implies that if only

[22] Note that if $p = 0$, the equilibrium is identical to the equilibrium derived in subsection 3.2 where only a verifiable performance measure was available.

weak supervisors are available, their bias is not a concern. This differs when supervisors are relatively strong, as shown in Proposition 4.

Proposition 4 *Suppose* $\eta > \varphi$. *If* $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ *and* $\varphi \leq \frac{1}{2}$, *or if* $p > \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$ *and* $\varphi > \frac{1}{2}$, *the optimal contract induces unbalanced efforts biased towards the SR.*
Under these conditions, the optimal contract has $c = \frac{\left(\sqrt{p(1-q)}+|1-2\eta|\sqrt{q}\right)^2}{2\left(\eta^2+(1-\eta)^2\right)}$, $b(m = \underline{m}) = 0$, *and* $b(m \neq \underline{m}) = -c$.
If $\eta > \frac{1}{2}$, $\underline{m} = \lambda\left((\eta\varphi + (1-\eta)(1-\varphi))\sqrt{p(1-q)} + (\eta-\varphi)\sqrt{q}\right)$ *and equilibrium effort levels are* $e_1 = \lambda\left(\eta\sqrt{p(1-q)} - (1-\eta)\sqrt{q}\right)$ *and* $e_2 = \lambda\left((1-\eta)\sqrt{p(1-q)} + \eta\sqrt{q}\right)$, *where* $\lambda = \frac{\left(\sqrt{p(1-q)}+|1-2\eta|\sqrt{q}\right)}{\left(\eta^2+(1-\eta)^2\right)}$.
If $\eta < \frac{1}{2}$, $\underline{m} = \lambda\left((\eta\varphi + (1-\eta)(1-\varphi))\sqrt{p(1-q)} - (\eta-\varphi)\sqrt{q}\right)$ *and equilibrium effort levels are* $e_1 = \lambda\left(\eta\sqrt{p(1-q)} + (1-\eta)\sqrt{q}\right)$ *and* $e_2 = \lambda\left((1-\eta)\sqrt{p(1-q)} - \eta\sqrt{q}\right)$.

Proof. The proof is given in the Appendix. ■

When the verifiable performance measure is ineffective, strong supervisors have an incentive to ignore the performance target $\underline{m}$ and deviate to their most-preferred effort ratio (SR). This reduces the agent's incentives, as it implies that the agent's bonus is forfeit if the performance measure provides a signal. However, if this probability q is small enough, the supervisor is still better off inducing the agent to allocate efforts along the SR. Figure 4 depicts this situation. The solid ICC curve gives the effort allocations the supervisor could induce provided that the penalty $b(m \neq \underline{m})$ would never be incurred, while the dashed ICC gives all implementable effort allocations if penalty $b(m \neq \underline{m})$ is incurred with probability q. From the supervisor's perspective, the best feasible effort allocation implementing $m = \underline{m}$ is the rightmost point on the thick segment of the $m = \underline{m}$ line. However, given that the supervisor is very effective compared to the verifiable measure, she can induce efforts off the $m = \underline{m}$ line that yield her higher utility, as depicted by the shaded area. Optimally, she would induce the agent to choose the effort levels determined by the intersection of the SR and the dashed ICC.

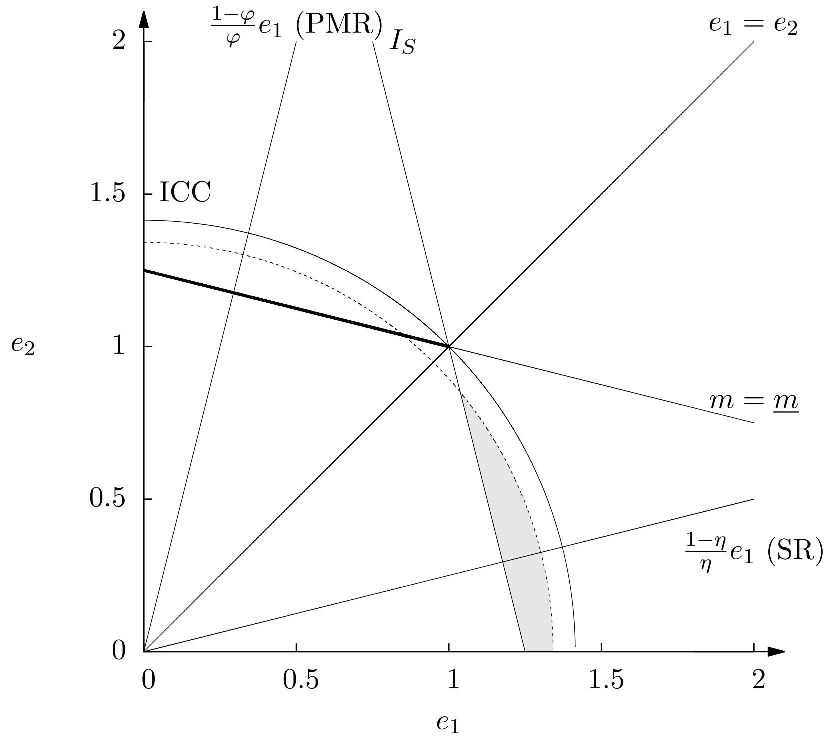

Figure 4: An example with $\eta = \frac{4}{5}$ and $\varphi = \frac{1}{5}$. For relatively low q, it is feasible and optimal for the supervisor to ignore $m = \underline{m}$, as shown by the shaded area.

Anticipating the supervisor's incentive to deviate, the principal optimally adjusts the contract. First, given bonus c, the principal adjusts the performance target $\underline{m}$ such that the supervisor can induce the agent to meet $m = \underline{m}$ with an effort allocation closer to SR. Given that $\eta > \varphi$, this adjustment is upward (downward) when $\eta < \frac{1}{2}$ ($\eta > \frac{1}{2}$). Second, as the implemented effort ratio is distorted, the principal optimally sets a smaller bonus.

Proposition 4 shows that a weak performance measure not only hampers the provision of incentives to the agent, but also makes monitoring the supervisor difficult. Strong supervisors use their information advantage to induce efforts that are biased towards their most-preferred task. To mitigate this problem, the principal must accommodate to the supervisor's preferences.[23] Given q, the imbalance in equilibrium efforts is increasing

[23]Note that if $q = 0$, the equilibrium is identical to the equilibrium derived in subsection 3.3 where only subjective performance evaluation was available. For $q = 0$, the (irrelevant) performance target $\underline{m}$ simply gives the performance as measured given the agent's efforts.

in p. However, this does not imply that the principal would prefer a less effective supervisor when verifiable performance measures are weak. Effective supervisors also reduce the agent's rents, which in turn makes implementing higher efforts more attractive to the principal. This positive effect on efficiency dominates the negative effect of a more biased outcome. Given supervisor effectiveness p, an increase in the supervisor's bias harms the principal.

The following proposition gives an overview of the comparative statics of all parameters on the optimal level of bonus pay and on the principal's payoff, for all cases considered above combined. As our linear-quadratic framework implies that the principal's payoff is equal to the agent's bonus pay, these comparative statics are identical.

Proposition 5 *Given $\eta > \varphi$, comparative statics on the optimal level of bonus pay and the principal's equilibrium payoff are as follows:*
(i) $\frac{\partial U_p}{\partial p} = \frac{\partial c}{\partial p} \geq 0$, *with equality only if* $q = 1$.
(ii) $\frac{\partial U_p}{\partial q} = \frac{\partial c}{\partial q} \geq 0$, *with equality only if* $p = 1$.
(iii) $\frac{\partial U_p}{\partial \varphi} = \frac{\partial c}{\partial \varphi} \geq 0$ *if* $\varphi < \frac{1}{2}$, *with equality only if* $p \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, *and* $\frac{\partial U_p}{\partial \varphi} = \frac{\partial c}{\partial \varphi} \leq 0$ *if* $\varphi > \frac{1}{2}$, *with equality only if* $p > \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$.
(iv) $\frac{\partial U_p}{\partial \eta} = \frac{\partial c}{\partial \eta} \geq 0$ *if* $\eta < \frac{1}{2}$, *with equality only if* $p \leq \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$, *and* $\frac{\partial U_p}{\partial \eta} = \frac{\partial c}{\partial \eta} \leq 0$ *if* $\eta > \frac{1}{2}$, *with equality only if* $\varphi < \frac{1}{2}$ *and* $p \leq \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ *or if* $\varphi > \frac{1}{2}$ *and* $p < \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$.

Proof. The proof is given in the Appendix. ■

To summarize our findings above, we find that the principal always benefits from more effective performance measurement and supervision. Both reduce the agent's rents and allow for stronger incentive pay. As the agent's rents in equilibrium depend on the probability that either the supervisor observes the agent's efforts or the principal receives a verifiable performance measure, the effectiveness of the supervisor and the verifiable measure are substitutes. A biased supervisor need not be detrimental to the principal, provided that the principal has access to a verifiable performance measure that is sufficiently effective and the supervisor is either less biased than the verifiable performance measure or biased towards the other task.[24]. However, when the verifiable performance measure is relatively weak, a biased supervisor forces the principal to accommodate to her preferences, leading to lower optimal incentive pay. Similarly, a biased performance measure is not problematic as long as the supervisor is sufficiently effective. If not, the agent's incentive to ignore the supervisor leads to an allocation of efforts biased towards the task that receives most weight in the performance measure.

The following proposition establishes that the principal is always better off combining subjective and objective performance evaluation compared to using only subjective or only objective performance evaluation. Combined evaluation always reduces the agent's rents, which benefits the principal. Furthermore, if both subjective and objective performance measurement are sufficiently effective, as studied in Propositions 1 and 2, combined evaluation can eliminate the bias that might arise when only using objective or subjective performance evaluation. On the other hand, if p and q are sufficiently different, combined evaluation might increase the bias as compared to using only objective or only subjective performance evaluation. Still, for all performance measures and all supervisors, the cost implied by the extra bias is outweighed by the benefits that arise from better monitoring of the agent. This result is close to Datar et al. (2001), who show that the use of an extra verifiable performance measure that increases incongruence is nevertheless optimal as long as it allows for more precise measurement of the agent's efforts.[25]

[24]It is possible to affect the supervisor's bias by offering a bonus to the supervisor based on measured performance m. Effectively, this would draw the supervisor's relative preferences over tasks closer to PMR. From Proposition 5, it follows that this benefits the principal only when the performance measure is relatively weak and less biased or biased towards the opposite task as the supervisor. However, given the supervisor's limited liability, providing a bonus to the supervisor is highly costly precisely when the verifiable measure is weak. Hence, incentive pay for the supervisor based on the agent's performance is of little use to the principal.

[25]We have assumed that the (fixed) cost of obtaining both the objective and the subjective performance measure is zero. If these costs are positive, a trade-off naturally arises.

Proposition 6 *When $p > 0$ and $q > 0$, the principal benefits from combining subjective and objective performance evaluation.*

Proof. The proof is given in the Appendix. ■

5 Generalists versus specialists as supervisors

We use our results to discuss the principal's trade-off when choosing between different supervisors. In particular, we consider the choice between a specialist and a generalist. We assume that a specialist is more effective in monitoring the agent than a generalist, $p_S > p_G$, where subscript S (G) denotes specialist (generalist). However, the specialist has stronger preferences regarding the execution of the tasks than the generalist. We assume that the generalist has unbiased preferences, $\eta_G = \frac{1}{2}$, while the specialist has biased preferences $\eta_S \neq \frac{1}{2}$. This combination of expertise and bias corresponds to findings by Li (2013), who looks at decision made by reviewers of grant proposals at the US National Institute of Health. She finds that reviewers are better able to judge the quality of proposals in their own area, but that they are also biased in favour of proposals in their own area. While the relation between grant reviewers and potential grant recipients differs from the relation between managers and employees, the reviewers decide about resource allocation across different fields, much like the supervisor in our model.

To determine whether the principal prefers a generalist or a specialist in the absence of verifiable performance measures, we can directly use the principal's payoff under pure discretionary pay (20). It follows that the principal prefers the specialist manager if

$$\frac{p_S}{p_G} > 2\left((1-\eta_S)^2 + \eta_S^2\right) \tag{23}$$

Hence, in choosing between a specialist and a generalist, the principal faces a trade-off between more effective supervision and more distorted effort levels. The principal tolerates the bias of the specialist only if she is sufficiently more effective than the generalist.

Now suppose that the principal has access to a verifiable performance measure. Without loss of generality, we focus on the case where $\eta_S > \frac{1}{2}$ and $\eta_S > \varphi$. Better performance measurement (higher q) affects the choice between the generalist and the specialist in two ways. First, the marginal benefit to the principal of a better supervisor is smaller, as the effectiveness of subjective and objective performance measurement are substitutes. Second, the principal can use the verifiable performance measure to neutralize or at least mitigate the bias that is induced by the specialist supervisor. The latter effect dominates, unless the specialist's bias cannot be fully eliminated.

Combining Propositions 1, 3, and 5, we have that if $\varphi \leq \frac{1}{2}$ and $p_S < \frac{1}{(1-2\eta_S)^2}\frac{q}{(1-q)}$ the supervisor's bias is irrelevant while the principal benefits from more effective supervision. It follows that the principal prefers the specialist: when the verifiable performance measure is sufficiently effective and biased towards the opposite task as compared to the specialist, the principal can neutralize the specialist's bias while obtaining the benefits from better supervision. On the other hand, if the objective measure is relatively weak, the principal is forced to accommodate towards the specialist's bias. If the bias of the specialist is sufficiently strong while she is only slightly more effective, the principal prefers the generalist (in the limit where $q = 0$, this condition is given by (23)). Interestingly, if $\varphi > \frac{1}{2}$ and the verifiable measure is sufficiently strong, the bias induced by a specialist supervisor is the bias of the verifiable performance measure. In this case, a more aligned objective performance measure (φ closer to $\frac{1}{2}$) makes the specialist more attractive, whereas a more effective objective performance measure (higher q) increases the relative attractiveness of the generalist. These results are summarized in the following proposition.

Proposition 7 *Consider the principal's choice of supervisor between a specialist and a generalist, where $\eta_S > \eta_G = \frac{1}{2}$ and $p_S > p_G$. The principal prefers the specialist over* *the generalist, unless (i)* $\eta_S > \varphi > \frac{1}{2}$ *and* $p_S < \frac{(\eta_S\varphi+(1-\eta_S)(1-\varphi))^2}{(\eta_S-\varphi)^2}\frac{q}{(1-q)}$ *or (ii)* $p_G > \frac{1}{(1-2\eta_S)^2}\frac{q}{(1-q)}$*. In case (i), if* $p_G \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$*, the principal prefers the generalist if and only if* $p_S - p_G < (1-2\varphi)^2\left(\frac{q}{(1-q)} + p_G\right)$*, while if* $p_G < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$*, the principal prefers the generalist if and only if* $p_S - p_G < \frac{2\sqrt{p_G}}{(1-q)}\left((2\varphi-1)\sqrt{(1-p_G)q} - 2\varphi(1-\varphi)\sqrt{p_G}\right)$*. In case (ii), the principal prefers the generalist if and only if* $p_S - p_G < \frac{\left((2\eta-1)\sqrt{p_S}-\sqrt{\frac{q}{(1-q)}}\right)^2}{2\left(\eta^2+(1-\eta)^2\right)}$*.*

Proof. The proof is given in the Appendix. ■

6 Concluding remarks

We have studied the effects of biased supervision in a three-tier hierarchy. Supervisors can influence their subordinates' effort allocation across tasks by (ab)using their discretion in determining subjective performance evaluations. This allows supervisors to direct their subordinates towards activities that have relatively high value for the supervisor but not necessarily for the organization. Biased supervision is detrimental for organizations in the absence of other performance measures, as it leads to misallocation of agents' effort across tasks. However, this negative effect of supervisor bias is mitigated when the principal can also use a verifiable performance measure, even when the latter is highly incongruent. A biased supervisor will use her discretionary powers to direct her agents away from the distortion inherent in the verifiable performance measure, towards tasks she considers more important. At the same time, the principal can use verifiable performance targets to constrain the supervisor. We have shown that the optimal level of incentive pay for employees is decreasing in supervisor bias only when the verifiable performance measure is weak.

We have derived the optimal contract assuming that the supervisor's bias and ability are observed by the principal. If the supervisor's type is unobservable and supervisors self-select into organizations, a given contract is most attractive to supervisors with high-ability and with a bias close to the bias of the verifiable performance measure.

This implies that in determining performance targets and the supervisor's discretion, the principal faces a trade-off between attracting aligned but low-ability supervisors and attracting high-ability but more biased supervisors. The effects of (incentive) wages on the self-selection of workers based on intrinsic motivation and/or ability is studied by e.g. Handy and Katz (1998), Besley and Ghatak (2005), Delfgaauw and Dur (2008, 2010), Prendergast (2007), and Dal Bo et al. (2013). How self-selection of managers is affected by the degree of discretion over their subordinates' activities is an interesting question that we leave for future work.

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A Appendix

Proof. [Proof of Lemma 1] Suppose the principal wants to induce some efforts $e^* = \{e_1^*, e_2^*\}$, which would lead to measured performance $m = \underline{m}$. First, suppose the supervisor also wants to induce e^*. Exerting effort e^* yields agent's expected utility

$$U_A(e^*) = pqw_A(\underline{m}, r_G) + p(1-q)w_A(\emptyset, r_G) + (1-p)qw_A(\underline{m}, r_G) + (1-p)(1-q)w_A(\emptyset, r_G) - \frac{1}{2}(e_1^*)^2 - \frac{1}{2}(e_2^*)^2$$

Provided that $\max_m w_A(m, r_G) = w_A(\underline{m}, r_G)$, assumption (5) implies $w_A(\emptyset, r_G) = w_A(\underline{m}, r_G)$, so that we can rewrite this to

$$U_A(e^*) = w_A(\underline{m}, r_G) - \frac{1}{2}(e_1^*)^2 - \frac{1}{2}(e_2^*)^2 \tag{A1}$$

The agent's rents (the difference between wage $w_A(\underline{m}, r_G)$ and the agent's effort cost) are determined by $\max_e U_A(e^{-*})$, where $U_A(e^{-*})$ represents the agent's expected utility after choosing any efforts $e \neq e^*$. For any $e \neq e^*$ such that $m \neq \underline{m}$, we have

$$U_A(e^{-*}) = qw_A(m \neq \underline{m}, r_B) + p(1-q)w_A(\emptyset, r_B) + (1-p)(1-q)w_A(\underline{m}, r_G) - \frac{1}{2}\left(e_1^{-*}\right)^2 - \frac{1}{2}\left(e_2^{-*}\right)^2 \tag{A2}$$

while for any $e \neq e^*$ such that $m = \underline{m}$, we have

$$U_A(e^{-*}) = pqw_A(\underline{m}, r_B) + p(1-q)w_A(\emptyset, r_B) + (1-p)w_A(\underline{m}, r_G) - \frac{1}{2}\left(e_1^{-*}\right)^2 - \frac{1}{2}\left(e_2^{-*}\right)^2$$

It follows that the agent's rents $\max_e U_A(e^{-*})$ are minimal when $w_A(m \neq \underline{m}, r_B) = w_A(\underline{m}, r_B) = w_A(\emptyset, r_B) = 0$. Hence, after a bad report, the agent's wage is optimally zero, independent of measured performance m.

Next, consider the supervisor's incentive to demand $e^S \neq e^*$. First, consider any e^S yielding $m = \underline{m}$. In terms of measured performance, the principal cannot distinguish between e^S and e^*. As a result, the effect of the wage scheme on the agent's incentive to exert e^S is identical to the incentive to exert e^* as discussed above. Hence, if effort cost at e^* are at least as large as effort cost at e^S, the principal cannot prevent the supervisor from inducing e^S. Second, consider any e^S yielding $m = m^S \neq \underline{m}$. Exerting e^S gives the agent expected utility

$$U_A(e^S) = qw_A(m \neq \underline{m}, r_G) + (1-q)w_A(\emptyset, r_G) - \frac{1}{2}\left(e_1^S\right)^2 - \frac{1}{2}\left(e_2^S\right)^2 \tag{A3}$$

Not following the supervisor's demand and exerting $e \neq e^S$ such that $m \neq m^S$ and $m \neq \underline{m}$ yields expected utility to the agent equal to

$$U_A(e \neq e^S) = qw_A(m \neq \underline{m}, r_B) + p(1-q)w_A(\emptyset, r_B) + (1-p)(1-q)w_A(\emptyset, r_G) - \frac{1}{2}(e_1)^2 - \frac{1}{2}(e_2)^2 \tag{A4}$$

while exerting $e \neq e^S$ such that $m = \underline{m} \neq m^S$ yields utility

$$U_A(e \neq e^S) = qw_A(\underline{m}, r_B) + p(1-q)w_A(\emptyset, r_B) + (1-p)(1-q)w_A(\emptyset, r_G) - \frac{1}{2}(e_1)^2 - \frac{1}{2}(e_2)^2$$

Lastly, the agent can exert $e \neq e^S$ such that $m = m^S$, which yields utility

$$\begin{aligned} U_A(e \neq e^S) &= pqw_A(m \neq \underline{m}, r_B) + p(1-q)w_A(\emptyset, r_B) + (1-p)qw_A(m \neq \underline{m}, r_G) + \\ &+ (1-p)(1-q)w_A(\emptyset, r_G) - \frac{1}{2}(e_1)^2 - \frac{1}{2}(e_2)^2 \end{aligned}$$

The set of e^S the supervisor can demand increases in the difference between $U_A(e^S)$ and $\max_e U_A(e \neq e^S)$. Hence, the principal wants to minimize this difference. It is not possible to set $w_A(m \neq \underline{m}, r_B) > w_A(m \neq \underline{m}, r_G)$ or $w_A(\emptyset, r_B) > w_A(\emptyset, r_G)$, as the cheap talk nature of the reports implies that the supervisor would increase the set e^S by switching the report labels. Hence, it is optimal for the principal to set $w_A(m \neq \underline{m}, r_G) = w_A(m \neq \underline{m}, r_B) = 0$. It follows that the agent's wage is optimally zero if $m \neq \underline{m}$, regardless of the supervisor's report.

By assumption (5), it follows from (A1) that $w_A(\emptyset, r_G) = 0$ is not possible as the agent's incentives to exert e^* are derived from $w_A(\underline{m}, r_G) > 0$. Lastly, we show that $w_A(\underline{m}, r_B) = w_A(\emptyset, r_B) > 0$ does not affect the supervisor's decision to induce e^S rather than e^*. We focus on the case where the agent's best alternative to following the supervisor's demand is an effort allocation such that $m \neq \underline{m}$. The case where the best alternative yields $m = \underline{m}$ is analog and therefore omitted. If the agent decides not to follow the supervisor's demands (either e^* or e^S), it follows from substituting for $w_A(m \neq \underline{m}, r_G) = w_A(m \neq \underline{m}, r_B) = 0$, $w_A(\emptyset, r_G) = w_A(\underline{m}, r_G)$, and $w_A(\emptyset, r_B) = w_A(\underline{m}, r_B)$ into (A2) and (A4) that exerting $e_1 = e_2 = 0$ is optimal. Using (A1), it follows that to demand e^*, $w_A(\underline{m}, r_G)$ and $w_A(\underline{m}, r_B)$ have to be such that

$$(p(1-q)+q)\, w_A(\underline{m}, r_G) - \frac{1}{2}(e_1^*)^2 - \frac{1}{2}(e_2^*)^2 \geq p(1-q)w_A(\underline{m}, r_B) \tag{A5}$$

Both the principal and the supervisor are best off when these equations hold with equality. Suppose that e^* is such that $\frac{e_2^*}{e_1^*} = \frac{1-\kappa}{\kappa}$, for any $\kappa \in [0,1]$. By (A5), this implies that $e_1^* = \kappa\sqrt{2\left(p(1-q)+q\right)w_A(\underline{m}, r_G) - 2p(1-q)w_A(\underline{m}, r_B)}$ and $e_2^* = \frac{1-\kappa}{\kappa}e_1^*$. Using supervisor's utility (4), a supervisor with bias η derives utility from inducing e^* equal to

$$U_S(e^*) = \left(\eta\kappa + (1-\eta)(1-\kappa)\right)\sqrt{2\left(p(1-q)+q\right)w_A(\underline{m}, r_G) - 2p(1-q)w_A(\underline{m}, r_B)}$$

Similarly, using (A3), it follows that the supervisor can demand e^S if

$$p(1-q)w_A(\underline{m}, r_G) - \frac{1}{2}\left(e_1^S\right)^2 - \frac{1}{2}\left(e_2^S\right)^2 \geq p(1-q)w_A(\underline{m}, r_B)$$

By (SR), a supervisor with bias η will optimally induce the agent to exert efforts such that $\frac{e_2^S}{e_1^S} = \frac{1-\eta}{\eta}$, leading to $e_1^S = \eta\sqrt{2p(1-q)\left(w_A(\underline{m}, r_G) - w_A(\underline{m}, r_B)\right)}$ and $e_2^S = \frac{1-\eta}{\eta}e_1^S$. Using (4), this yields

$$U_S(e^S) = \left(\eta^2 + (1-\eta)^2\right)\sqrt{2p(1-q)\left(w_A(\underline{m}, r_G) - w_A(\underline{m}, r_B)\right)}$$

The supervisor prefers to induce e^S rather than e^* if $U_S(e^*) < U_S(e^S)$. Now consider an increase in $w_A(\underline{m}, r_B)$. This gives

$$\frac{\partial U_S(e^*)}{\partial w_A(\underline{m}, r_B)} = -\left(\eta\kappa + (1-\eta)(1-\kappa)\right)\frac{p(1-q)}{\sqrt{2\left(p(1-q)+q\right)w_A(\underline{m}, r_G) - 2p(1-q)w_A(\underline{m}, r_B)}}$$

$$\frac{\partial U_S(e^S)}{\partial w_A(\underline{m}, r_B)} = -\left(\eta^2 + (1-\eta)^2\right)\frac{p(1-q)}{\sqrt{2p(1-q)\left(w_A(\underline{m}, r_G) - w_A(\underline{m}, r_B)\right)}}$$

It follows that if $U_S(e^*) < U_S(e^S)$, we also have $\frac{\partial U_S(e^*)}{\partial w_A(\underline{m}, r_B)} < \frac{\partial U_S(e^S)}{\partial w_A(\underline{m}, r_B)}$. If the supervisor prefers some feasible e^S over e^*, an increase in $w_A(\underline{m}, r_B)$ (and, hence, $w_A(\emptyset, r_B)$) does not induce the supervisor to demand e^*. Hence, given that the agent's rents increases in $w_A(\underline{m}, r_B)$ as shown above, it is optimal to set $w_A(\underline{m}, r_B) = w_A(\emptyset, r_B) = 0$. After a bad report, the agent optimally receives no pay, regardless of measured performance. ■

Proof. [Proof of Proposition 1] Condition (i) follows from Lemma 2, while verifiable performance pay $b(m = \underline{m}) = 0$ and $b(m \neq \underline{m}) = -c$ follows from Lemma 1. Let $\varphi \leq \frac{1}{2}$. Given c, $\underline{m}$, $b(m = \underline{m}) = 0$, and $b(m \neq \underline{m}) = -c$, the supervisor maximizes utility (4) with respect to requested effort levels $\underline{e_1}$ and $\underline{e_2}$, subject to the agent's incentive compatibility constraint. If the supervisor requests effort levels that yield $m = \underline{m}$, this constraint is given by (22). If the first term between braces in (22) is larger than the second term, the supervisor optimally requests

$$\underline{e_1} = \frac{\varphi}{\varphi^2 + (1-\varphi)^2}\underline{m} + \frac{(1-\varphi)}{\varphi^2 + (1-\varphi)^2}\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)\,c - \underline{m}^2} \tag{A6}$$

$$\underline{e_2} = \frac{(1-\varphi)}{\varphi^2 + (1-\varphi)^2}\underline{m} - \frac{\varphi}{\varphi^2 + (1-\varphi)^2}\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)\,c - \underline{m}^2} \tag{A7}$$

Anticipating this, the principal maximizes utility (1) with respect to c and $\underline{m}$. The first-order conditions for c and $\underline{m}$ are, respectively, given by

$$\frac{(1-2\varphi)\,(p + (1-p)\,q)}{\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)\,c - \underline{m}^2}} - 1 = 0$$

$$\frac{1}{\varphi^2 + (1-\varphi)^2}\left(1 - \frac{(1-2\varphi)\,\underline{m}}{\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)\,c - \underline{m}^2}}\right) = 0$$

This can be solved for $c = \underline{m} = (p + (1-p)\,q)$. Substituting for c and $\underline{m}$ in (A6) and (A7) yields effort levels $\underline{e_1} = \underline{e_2} = (p + (1-p)\,q)$.

This solution is not attainable if the agent prefers to feign compliance to the supervisor request by generating $m = \underline{m}$ at lower effort cost through effort levels along the performance measure's effort ratio (PMR). This arises if the second term between braces in (22) is larger than the first term. Substituting for c and $\underline{m}$ yields condition $p \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$. The second condition on p follows from the supervisor's incentive to ignore performance target $\underline{m}$ and request effort levels along her preferred effort ratio

(SR). When ignoring $\underline{m}$, the supervisor optimally requests

$$\underline{e_1} = \eta\sqrt{\frac{2p(1-q)c}{\eta^2+(1-\eta)^2}} \tag{A8}$$

$$\underline{e_2} = (1-\eta)\sqrt{\frac{2p(1-q)c}{\eta^2+(1-\eta)^2}} \tag{A9}$$

where we have used that the agent's incentive compatibility constraint is now given by

$$(1-q)c - \frac{1}{2}\underline{e_1}^2 - \frac{1}{2}\underline{e_2}^2 \geq (1-q)(1-p)c$$

Note that the agent cannot feign compliance in this case, as the principal denies the bonus after learning that $m \neq \underline{m}$. Comparing supervisor utility levels from adhering to and ignoring $\underline{m}$ gives the following condition under which the supervisor prefers to adhere to performance target $\underline{m}$:

$$(p+(1-p)q) \geq \sqrt{2\left(\eta^2+(1-\eta)^2\right)p(1-q)(p+(1-p)q)}$$

which can be rewritten to $p \leq \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ as given in the proposition. ■

Proof. [Proof of Proposition 2] By Lemma 2, it is not possible to induce $\frac{e_2}{e_1} > \frac{1-\varphi}{\varphi}$, while verifiable performance pay $b(m = \underline{m}) = 0$ and $b(m \neq \underline{m}) = -c$ follows from Lemma 1. For given c and $\underline{m}$, the supervisor maximizes utility (4) with respect to requested effort levels $\underline{e_1}$ and $\underline{e_2}$, subject to the agent's incentive compatibility constraint (22). Assuming the first term between braces in (22) is larger than the second term, the supervisor optimally requests effort levels as given by (A6) and (A7). Substituting for $\underline{e_1}$ and $\underline{e_2}$ into the principal's utility (1) gives

$$U_P = \frac{1}{\varphi^2+(1-\varphi)^2}\underline{m} + \frac{(1-2\varphi)}{\varphi^2+(1-\varphi)^2}\sqrt{2\left(\varphi^2+(1-\varphi)^2\right)(p+(1-p)q)c - \underline{m}^2} - a - c - w_s \tag{A10}$$

By $\varphi > \frac{1}{2}$, the second term in (A10) is non-positive and decreasing in c. Note that the second term gives the principal's benefit of allowing the supervisor to implement an effort ratio different from (PMR). This implies that the optimal solution must have the smallest c possible given $\underline{m}$, as determined by

$$2\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)\,c - \underline{m}^2 = 0 \tag{A11}$$

Using this condition to substitute for c in (A10) and maximizing with respect to $\underline{m}$ gives first order condition

$$\frac{1}{\varphi^2 + (1-\varphi)^2} - \frac{\underline{m}}{\left(\varphi^2 + (1-\varphi)^2\right)(p + (1-p)\,q)} = 0$$

which yields $\underline{m} = (p + (1-p)\,q)$. Substituting for $\underline{m}$ in (A11) gives $c = \frac{(p+(1-p)q)}{2\left(\varphi^2+(1-\varphi)^2\right)}$, and the effort levels follow from substituting for $\underline{m}$ and c in (A6) and (A7).

As the agent exerts effort levels along the PMR, the two terms between braces in (22) coincide, implying that feigning compliance by generating $m = \underline{m}$ with different effort levels never benefits the agent. The supervisor prefers adhering to the principal's demand $m = \underline{m}$ rather than deviating to the best-possible effort allocation along her most-preferred effort ratio (SR) when

$$(\eta\varphi + (1-\eta)(1-\varphi))\sqrt{(p + (1-p)\,q)} \geq \sqrt{\left(\eta^2 + (1-\eta)^2\right)\left(\varphi^2 + (1-\varphi)^2\right)p\,(1-q)}$$

where the left-hand side (right-hand side) follows from substituting for the effort levels (A6) and (A7) ((A8) and (A9)) into the supervisor's utility (4). Rewriting yields the condition on p as given in the proposition. ■

Proof. [Proof of Proposition 3] If $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, the optimal contract derived in Proposition 1 is not attainable. The agent has an incentive to deviate to the effort levels on the performance measure's effort ratio (PMR) that generate $m = \underline{m}$ at lower effort cost (i.e. in the agent's incentive compatibility constraint (22), the second term in braces is larger than the first). Anticipating this, the supervisor would maximize her utility (4) with respect to effort requests $\underline{e_1}$ and $\underline{e_2}$. Assuming (for now) that the supervisor requests satisfy performance target $m = \underline{m}$, the optimal effort request is given by

$$\begin{aligned}
\underline{e_1} &= \frac{\varphi}{\varphi^2 + (1-\varphi)^2}\underline{m} + \frac{(1-\varphi)}{\varphi^2 + (1-\varphi)^2}\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)pc} \\
\underline{e_2} &= \frac{(1-\varphi)}{\varphi^2 + (1-\varphi)^2}\underline{m} - \frac{\varphi}{\varphi^2 + (1-\varphi)^2}\sqrt{2\left(\varphi^2 + (1-\varphi)^2\right)pc}
\end{aligned}$$

implying that given $\varphi < \frac{1}{2}$, the contract specified in Proposition 1 (with $c = \underline{m}$) would lead to $\frac{\varphi}{1-\varphi} < \frac{\underline{e_1}}{\underline{e_2}} < 1$.

This outcome would yield higher rents to the agent than exerting zero effort, as determined by the first term between braces in (22). It follows that the principal can achieve the same effort allocation at lower cost by adjusting c and $\underline{m}$ such that the two terms between braces in (22) are equal. In other words, the principal is constrained by the agent's temptation to resort to effort allocations on the PMR. This constraint is given by equating the two terms between braces in (22), which yields $c = \frac{1}{2(1-p)q}\frac{1}{\varphi^2+(1-\varphi)^2}\underline{m}^2$. The optimal contract follows from substituting for effort levels (A6) and (A7) and for c into the principal's utility (1) and maximizing with respect to a, $\underline{m}$, and w_s (as before, verifiable performance pay $b(m = \underline{m}) = 0$ and $b(m \neq \underline{m}) = -c$ follows from Lemma 1). The first-order condition for $\underline{m}$ is given by

$$1 + (1-2\varphi)\sqrt{\frac{p}{(1-p)q}} - \frac{1}{(1-p)q}\underline{m} = 0$$

This can be rewritten to $\underline{m} = (1-p)q + (1-2\varphi)\sqrt{p(1-p)q}$, yielding $c = \frac{\left(\sqrt{(1-p)q}+(1-2\varphi)\sqrt{p}\right)^2}{2\left(\varphi^2+(1-\varphi)^2\right)}$. The effort levels follow from substituting for c into (A6) and (A7). Given that $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, we have $c < p + (1-p)q < \underline{m}$.

Lastly, we must show that the supervisor optimally adheres to $m = \underline{m}$. The best deviation is to request effort levels along his preferred effort ratio (SR). In that case, the agent receives no bonus if the principal observes objective performance m, which happens with probability q. This implies that the agent's incentive constraint given deviation equals

$$(1-q)c - \frac{1}{2}\underline{e_1}^2 - \frac{1}{2}\underline{e_2}^2 \geq (1-q)(1-p)c$$

Note that if the supervisor deviates, the agent has no incentive to feign compliance because as $m \neq \underline{m}$, the bonus is forfeit if the verifiable measure provides a signal. Given bonus c, the deviating supervisor optimally requests effort levels

$$\begin{aligned} \underline{e_1} &= \eta\sqrt{\frac{2(1-q)pc}{\eta^2 + (1-\eta)^2}} \\ \underline{e_2} &= (1-\eta)\sqrt{\frac{2(1-q)pc}{\eta^2 + (1-\eta)^2}} \end{aligned} \quad \text{(A12)}$$

It is easily derived that given $\varphi < \frac{1}{2}$, the incentive to deviate is strongest for the supervisor most biased towards task 1, i.e. with $\eta = 1$. Below we show that even supervisors with $\eta = 1$ prefer to adhere to $m = \underline{m}$. Given $\eta = 1$, this implies that we have to show that effort in task 1 is lower when the supervisor deviates. Substituting for c, $\underline{m}$, and $\eta = 1$ into (A6) and (A12) implies that the supervisor adheres to $m = \underline{m}$ when

$$\frac{1}{\varphi^2 + (1-\varphi)^2}\left(\varphi(1-p)q + \left(1-2\varphi^2\right)\sqrt{p(1-p)q} + (1-\varphi)(1-2\varphi)p\right) > \left(\sqrt{(1-p)q} + (1-2\varphi)\sqrt{p}\right)\sqrt{\frac{(1-q)p}{\left(\varphi^2 + (1-\varphi)^2\right)}}$$

It can be shown that this expression increases in q. Rewriting condition $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, the lowest value of q considered in Proposition 3 is given by $q = \frac{p}{(1-p)(1-2\varphi)^2}$. Substituting for this level of q yields

$$\frac{2p\left(\varphi^2+(1-\varphi)^2\right)}{(1-2\varphi)^2}\left(\sqrt{\varphi^2+(1-\varphi)^2}-\sqrt{\left((1-2\varphi)^2-\frac{p}{1-p}\right)}\right)\geq 0$$

which holds for any φ and p, as $\varphi^2+(1-\varphi)^2 \geq (1-2\varphi)^2$ given that $0 \leq \varphi \leq 1$. Hence, supervisors optimally adhere to $m = \underline{m}$. ∎

Proof. [Proof of Proposition 4] If $\varphi \leq \frac{1}{2}$ and $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$, the optimal contract derived in Proposition 1 is not attainable. Similarly, if $\varphi > \frac{1}{2}$ and $p > \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$, the optimal contract derived in Proposition 2 is not feasible. In both cases, the supervisor has an incentive to deviate from inducing efforts that would satisfy $m = \underline{m}$ (i.e. (A6) and (A7)) to efforts along her most-preferred effort ratio (SR), as given by (A8) and (A9). Anticipating this, the principal must design a contract that meets the supervisor's incentive compatibility constraint:

$$\frac{\eta\varphi+(1-\eta)(1-\varphi)}{\varphi^2+(1-\varphi)^2}\underline{m}+\frac{\eta-\varphi}{\varphi^2+(1-\varphi)^2}\sqrt{2\left(\varphi^2+(1-\varphi)^2\right)(p+(1-p)q)c-\underline{m}^2}\geq \tag{A13}$$

$$\sqrt{2\left(\eta^2+(1-\eta)^2\right)(1-q)pc}$$

where the left-hand side gives the supervisor's utility when meeting the principal's target and the right-hand side gives his utility when ignoring this target, both following from substituting the effort levels into supervisor utility (4).

As before, verifiable performance pay $b(m = \underline{m}) = 0$ and $b(m \neq \underline{m}) = -c$ follows from Lemma 1. The optimal contract follows from substituting for effort levels (A6) and (A7) into the principal's utility (1) and maximizing with respect to c and $\underline{m}$, taking into account the limited liability constraints and the binding supervisor's incentive compatibility constraint (A13). Solving the Lagrangian gives lengthy first-order conditions, which, after straightforward (but tedious) rewriting, yield the expressions for c and $\underline{m}$

given in the proposition. Substituting for c and $\underline{m}$ into effort levels (A6) and (A7) yields the expressions for e_1 and e_2. ■

Proof. [Proof of Proposition 5] Substituting for $a = w_s = 0$ into the principal's utility (1) gives the principal's equilibrium payoff as $U_p = e_1 + e_2 - c$. Substituting for the optimal bonus c and equilibrium effort as given in Propositions 1-4 yields the following expressions for the principal's payoff U_p^i, where the superscript $i \in [1, 4]$ indicates the corresponding proposition (with some abuse of notation):

$$\begin{aligned}
U_p^1 &= p + (1-p)\,q \\
U_p^2 &= \frac{p + (1-p)\,q}{2\left(\varphi^2 + (1-\varphi)^2\right)} \\
U_p^3 &= \frac{\left(\sqrt{(1-p)q} + (1-2\varphi)\sqrt{p}\right)^2}{2\left(\varphi^2 + (1-\varphi)^2\right)} \\
U_p^4 &= \frac{\left(\sqrt{p\,(1-q)} + |1-2\eta|\sqrt{q}\right)^2}{2\left(\eta^2 + (1-\eta)^2\right)}
\end{aligned}$$

Note that all payoffs are identical to the corresponding levels of bonus pay c. Hence, all comparative statics are identical too.

First, we determine the comparative statics within each proposition.

(i) The (weakly) positive effect of p follows directly for Propositions 1, 2, and 4. For Proposition 3, we have $\frac{\partial U_p^3}{\partial p} = -\frac{\sqrt{p}q-(1-2\varphi)\sqrt{(1-p)q}}{2\sqrt{p}\sqrt{(1-p)q}} > 0$, where the sign follows from the conditions $\varphi \leq \frac{1}{2}$ and $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$ under which this Proposition is relevant.

(ii) The (weakly) positive effect of q follows directly for Propositions 1, 2, and 3. For Proposition 4, we have $\frac{\partial U_p^4}{\partial q} = -\frac{\sqrt{q}p-(1-2\eta)\sqrt{p(1-q)}}{2\sqrt{q}\sqrt{p(1-q)}} > 0$, where the sign follows from the conditions $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ or from $\eta > \varphi > \frac{1}{2}$ and $p > \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$ under which this Proposition is relevant.

(iii) Under the conditions governing Propositions 1 and 4, φ has no effect on U_p. In

Proposition 2, the principal's payoff is decreasing in the bias $|\varphi - \frac{1}{2}|$. In Proposition 3, we have $\frac{\partial U_p^3}{\partial \varphi} = -\frac{(1-2\varphi)(p-q+pq)+4\varphi(1-\varphi)\sqrt{p(1-p)q}}{\left(\varphi^2+(1-\varphi)^2\right)^2}$, which is also decreasing in bias $|\varphi - \frac{1}{2}|$ when $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$.

(iv) The supervisor's bias matters only under the conditions that make Proposition 4 relevant. Then, $\frac{\partial U_p^4}{\partial \eta} = -\frac{(1-2\eta)(q-p+pq)+4\eta(1-\eta)\sqrt{p(1-q)q}}{\left(\eta^2+(1-\eta)^2\right)^2}$, which decreases in supervisor bias $|\eta - \frac{1}{2}|$ when $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ as well as when $p > \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$ and $\eta > \varphi > \frac{1}{2}$.

Second, we compare the principal's payoffs at the exact parameter thresholds that determine which proposition is relevant. Substituting for $\varphi = \frac{1}{2}$ into U_p^2, we have $U_p^1 = U_p^2$. Similarly, when $p = \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, we have $U_p^1 = U_p^3$, and when $p = \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ we have that $U_p^1 = U_p^4$. Lastly, when $p = \frac{(\eta\varphi+(1-\eta)(1-\varphi))^2}{(\eta-\varphi)^2}\frac{q}{(1-q)}$ and $\eta > \varphi > \frac{1}{2}$ we have that $U_p^2 = U_p^4$. Hence, given $\eta > \varphi$, marginal changes in parameter values do not lead to jumps in the principal's payoff. ■

Proof. [Proof of Proposition 6] We focus again on the case of $\eta > \varphi$. Comparing the principal's payoff when using objective performance evaluation only and subjective performance evaluation only, as given by (12) and (20), respectively, to the payoffs when combining them, as given by U_p^i as defined in the proof to Proposition 4, it follows directly that U_p^1 and U_p^2 are (weakly) larger than (12) and (20). Hence, if both p and q are large enough (i.e. when $\frac{1}{(1-2\eta)^2}\frac{q}{(1-q)} \geq p \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$), combining objective and subjective performance evaluation yields lower rents to the agent and, unless $\eta > \varphi > \frac{1}{2}$, eliminates the bias that might arise when using only objective or only subjective performance evaluation. Both effects increase the principal's payoff. Next, suppose that $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, such that the outcome with combined evaluation is biased towards PMR (Proposition 3). Even when the supervisor would be unbiased ($\eta = \frac{1}{2}$), the principal benefits from also using the verifiable performance measure: U_p^3 exceeds (20) for any $p < \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$. Similarly, if $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$, such that combined evaluation results in a bias towards the SR, the principal benefits from also using subjective performance evaluation, as U_p^4 is larger than (12) for any $p > \frac{1}{(1-2\eta)^2}\frac{q}{(1-q)}$ even when $\varphi = \frac{1}{2}$. ■

Proof. [Proof of Proposition 7] If $p_S < \frac{(\eta_S\varphi+(1-\eta_S)(1-\varphi))^2}{(\eta_S-\varphi)^2}\frac{q}{(1-q)}$ and $\varphi \leq \frac{1}{2}$ or $\varphi > \eta_S > \frac{1}{2}$, the principal's payoff with both supervisors is either U_p^1 or U_p^3, which are both increasing in p and independent of η. Hence, the principal prefers the specialist. Similarly, if $p_S > \frac{1}{(1-2\eta_S)^2}\frac{q}{(1-q)} > p_G$, the specialist yields principal's payoff U_p^4, while the generalist yields payoff U_p^1. Result (i) in Proposition 5 showed that starting from U_p^1, an increase in p such that the principal is forced to allow for a bias, yielding payoff U_p^4, benefits the principal for any η. This proves the first part. When $\eta_S > \varphi > \frac{1}{2}$ and $p_S < \frac{(\eta_S\varphi+(1-\eta_S)(1-\varphi))^2}{(\eta_S-\varphi)^2}\frac{q}{(1-q)}$, employing the specialist supervisor yields payoff U_p^2. Employing the generalist yields U_p^1 if $p_G \geq \frac{q(1-2\varphi)^2}{1+q(1-2\varphi)^2}$, otherwise it yields $U_p = \frac{\left(\sqrt{(1-p)q}+(2\varphi-1)\sqrt{p}\right)^2}{2\left(\varphi^2+(1-\varphi)^2\right)}$. Note that the latter expression mirrors U_p^3, and holds for $\eta < \varphi$ and $\varphi > \frac{1}{2}$ (here relevant when employing a generalist as $\eta_G = \frac{1}{2}$), while U_p^3 is derived under the conditions $\eta < \varphi$ and $\varphi > \frac{1}{2}$ (see Proposition 3). Comparing these payoffs yield the two conditions in case (i), respectively. Lastly, when $p_G > \frac{1}{(1-2\eta_S)^2}\frac{q}{(1-q)}$, the specialist yields principal's payoff U_p^4, while the generalist yields payoff U_p^1. Comparing these payoffs gives the condition in the proposition. ■