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Are you a Good Employee or Simply a Good Guy?

Influence Costs and Contract Design

May 20, 2013

Abstract

We develop a principal-agent model with a moral hazard problem in which the principal has access to a hard signal (the level of output) and a soft behavioral signal (the supervision signal) about the agent's level of effort. In our model, the agent can initiate influence activities and manipulate the behavioral signal. These activities are costly for the principal as they detract the agent from the productive task. We show that the agent's ability to manipulate the behavioral signal leads to low-powered incentives and increases the cost of implementing the efficient equilibrium as a result. Interestingly, the fact that manipulation activities entail productivity losses may lead to the design of influence-free contracts that deter manipulation and lead to high-powered incentives. This result implies that the optimal contract (and whether manipulation is tolerated in equilibrium or not) depends on the magnitude of the productivity-based influence costs. We show that it may be optimal for the principal not to supervise the agent, even if the cost of supervision is arbitrarily low (JEL D23, D82).

Keywords: principal-agent model with supervision, moral hazard problem, contract design, influence activities, manipulation, productivity-based influence costs, power of incentives.

1 Introduction

Recent financial scandals including the Madoff's case of felony or the distortion of budget figures by the Greek government, raise questions about the manipulability of information. In this article we study this issue in a principal-agent setup, in which the agent is given the possibility to influence the principal's evaluation of his work by manipulating certain pieces of information through the use of influence activities that distort the principal's evaluation of his performance if the principal engages in supervision.¹ Examples in that direction

¹Hereafter, we use the feminine pronouns for the principal and masculine for the agent.

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9 include an agent who invites his boss for a coffee or an agent who dresses or behaves in a particular way to
10 make his supervisor feel he is more professional.

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12 We assume that these activities have a cost for the agent and are aimed to manipulate the behavioral
13 signal collected by the principal. This way of modeling influence is related to the work of Mullainathan,
14 Schwartzstein and Shleiffer (2008) who consider the idea of associative thinking. In their framework, individ-
15 uals classify situations into categories, and transfer the informational content of a given signal from situations
16 in a category where it is useful to those where it is not.² Applying this concept to our model, the principal
17 who dedicates time to monitor the agent will find it difficult to distinguish the following positive pieces of
18 information " *The agent is a hard-working (good) employee*" and " *The agent is a good person*". These pieces
19 of information belong to two different categories, work abilities and personality, and the difficulty for the
20 principal is to disentangle signals that concern the contribution of their employee to the firm and the ones
21 that relate to personal characteristics. Specifically, we model influence as a reduced form of coarse thinking
22 by considering that the principal suffers from biased information processing à la Bénabou and Tirole (2002).
23 As a result, the principal may misperceive a negative behavioral signal about the level of effort of the agent
24 as being positive.

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26 A comprehensive analysis of the manipulability of information requires a precise understanding of the
27 relation between the concepts of hard and soft information. In the finance literature, hard information is
28 defined as being quantitative (Berger et al., 2001; Stein, 2002; Petersen, 2004; Liberti and Mian, 2009). Hard
29 information is assumed to be easy to store, to be transmitted in impersonal ways and to be independent of
30 the collection process; all these features making it a priori difficult for hard information to be manipulated.
31 Further, research on supervision and delegation in principal-agent models refer to hard information as being
32 verifiable (Tirole, 1986) whereas soft information is considered to be unverifiable (Baliga, 1999; Faure-
33 Grimaud, Laffont and Martimort, 2003). In these models, a signal is unverifiable whenever it cannot be
34 observed by a third party (the "judge"). Manipulability of information implies that soft information can be
35 distorted whereas hard information can simply be hidden.

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37 In the current article, we consider a principal-agent model, in which the principal has access to both,
38 hard and soft information about the agent's level of effort. We assume that hard information cannot be
39 manipulated whereas soft information is subject to manipulation attempts. In our framework, agents do not
40 distort or hide their own pieces of information but undertake influence activities in order to manipulate the
41 soft signal collected by the principal.

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43 ²Persuasion has also been modeled using an informational approach (Milgrom and Roberts, 1986; Dewatripont and Tirole,
44 1999).

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9 The consideration of both hard and soft signals relates our study to the literature on subjective evaluations
10 (Baker, Gibbons and Murphy, 1994; MacLeod, 2003). In our model, similarly to the analysis developed in
11 Baker, Gibbons and Murphy (1994), the principal can propose contingent contracts that depend on a hard
12 signal (determined by the level of production) as well as on a soft (behavioral) signal, which provides
13 additional information about the level of effort of the agent. However, in contrast with the model of Baker,
14 Gibbons and Murphy (1994) and the general framework of MacLeod (2003), we assume that both the
15 principal and the agent agree on the value of the soft signal so that the signal can be treated as if it were
16 verifiable. As a result, we can disentangle the issues related to the unverifiability of subjective evaluations
17 (MacLeod, 2003) from the issues related to the manipulability of such evaluations.
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23 24 25 **1.1 The costs and benefits of influence activities**

26 Influence activities have been identified as actions completed by organizational members in order to bias the
27 decisions of managers toward more pay and promotions (Milgrom, 1988; Milgrom and Roberts, 1988, 1992).³
28 As a general principle, this analysis suggests that influence costs can be reduced by limiting the discretion
29 of decision makers for those decisions that have a significant impact on the distribution of rents inside the
30 organizations but that have minor impact on the firm's profits.⁴
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33 In our model, we focus on optimal contracts rather than organizational design as a mechanism to reduce
34 influence costs. In our framework, influence costs are not only incurred by the agent. Influence activities
35 may also entail costs in terms of the firm's productive activities as is suggested in the original definition of
36 Milgrom (1988).
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42 "That time of course is valuable; if it were not wasted in influence activities, it could be used for
43 directly productive activities or simply consumed as leisure."
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46 We assume that influence activities are unverifiable so that the principal cannot prevent influence simply
47 by punishing manipulation attempts. In our model, influence activities tend to reduce aggregate welfare by
48 increasing information asymmetry between principal and agent. As a result, the agent's ability to manipulate
49 the soft signal increases the cost of implementing the high level of effort in equilibrium.
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52 Our approach differs from the model developed by Maggi and Rodríguez-Clare (1995) in which agents
53 can distort the principal's private information in order to reduce information asymmetry. In their setting,
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55 ³Also, notice that influence costs have been considered as a key element of the theory of the firm (Gibbons, 2005).

56 ⁴Milgrom (1988) also mentions the use of compensation schemes as one of the possible instruments with which to reduce
57 influence activities. In particular, the author puts forward that the compression of wage differentials between current jobs and
58 promotion jobs is an effective strategy for reducing incentives to influence the manager's promotion decision.
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9 information distortion may actually allow for the falsification of information in equilibrium, and as a result,
10 may increase aggregate welfare. Relatedly, Croker and Morgan (1998) study sharecropping and insurance
11 optimal contracts showing that falsification is pervasive in equilibrium. In their setup, the agent who
12 possesses private information about the contractible outcome (e.g., the size of the crop or the value of a
13 loss) will misreport it in equilibrium given that the optimal contract provides overinsurance for small losses
14 and underinsurance for severe ones. Misreporting in a principal-agent setting has also been studied in
15 contexts in which the result of the privately observed information is affected by the agent undertaking a
16 hidden action (Crocker and Slemrod, 2007; Crocker and Gresik, 2011; Beyer, Guttman and Marinovic, 2012;
17 Roger, 2012).⁵
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24 1.2 Incentive Schemes under Influence

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26 In our setting, the principal will decide upon the optimal incentive scheme by comparing influence contracts
27 that tolerate some influence activities in equilibrium and influence-free contracts that eliminate all manip-
28 ulation attempts. In our framework, there exists conditions, which critically depend on the magnitude of
29 influence costs, under which influence-free contracts are dominated by contracts that permit some degree of
30 influence. The main difference between our work and the previous literature on information manipulation
31 (Maggi and Rodríguez-Clare, 1995; Crocker and Morgan, 1998; Crocker and Slemrod, 2007; Crocker and
32 Gresik, 2011; Beyer, Guttman and Marinovic, 2012; Royer, 2012) is that influence activities are modeled
33 differently from falsification. In falsification models, an agent observes a piece of information privately which
34 he can choose to manipulate or not at a personal cost. In our influence model, the agent does not have
35 any private information regarding the behavioral signal which he may attempt to influence. As a result, the
36 application of the revelation principle to our setting is trivial.
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44 We show that the cost of implementing the efficient equilibrium increases as the behavioral signal becomes
45 more manipulable and influence activities are more pervasive. This occurs because in the presence of influence
46 activities the principal relies on less informative signals and must, as a result, increase the variance of wages
47 in order to keep incentives intact. This implies that a larger rent will have to be paid to the risk-averse agent
48 in order to ensure that the participation constraint holds. This result follows from Kim (1995) after showing
49 that the efficiency of the information structure decreases in the manipulability of the behavioral signal.
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53 We show that optimal wages become more compressed and less volatile as the behavioral signal becomes

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55 ⁵The results in these papers differ from Lacker and Weinberg (1989), who characterize the optimal contract that induces
56 no-manipulation in equilibrium. As is discussed by Croker and Morgan (1998), a correct application of the revelation principle
57 implies that the contract in Lacker and Weinberg (1989) will be dominated by one that allows for falsification.
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9 more manipulable. In addition, more weight is given to the hard signal in the payment scheme in the
10 presence of highly manipulable behavioral signals. These results are closely related to the sufficient statistic
11 theorem (Holmström, 1979; Banker and Datar, 1989) according to which incentive contracts must include
12 all the signals that are informative about the agent's level of effort. Indeed, incentive schemes will be less
13 responsive to the behavioral signal as it becomes more manipulable (and therefore less informative).⁶

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17 Interestingly, our model of influence does not necessarily lead to low-powered incentives. The fact that
18 engaging in influence activities affects the agent's productivity negatively is crucial in understanding why
19 our model may induce high-powered incentives. Indeed, the principal who designs influence-free contracts
20 in equilibrium follows the strategy that consists of increasing the opportunity cost associated with influence
21 activities by increasing the incentives associated with the hard signal. In that case, influence activities
22 become less attractive as they reduce the probability that the agent will get the high payment associated
23 with a high level of performance on the hard signal. As a result, the principal may be willing to design
24 high-powered incentive contracts to deter influence activities. More specifically, we show that high-powered
25 incentives and influence-free contracts are more likely to be offered to high-productivity agents for which
26 influence is especially costly in terms of firm productivity than to low-productivity agents. Also, we show that
27 the incentive contracts of high-productivity agents tend to be more responsive to the hard signal compared
28 with low-productivity agents.⁷

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36 Finally, we show that the principal may decide not to supervise the agent in equilibrium, even though
37 the cost of supervision is arbitrarily low. Supervising the agent to collect an additional informative signal is
38 crucial for the principal's ability to implement the high level of effort. However, when the principal's bias is
39 severe, it may become too costly for the principal to use the supervision signal to induce the agent to exert
40 high effort. This is the case because a high level of manipulability of the supervision signal undermines its
41 informativeness significantly forcing the principal to increase wages to sustain the high level of effort. In
42 that case, the principal may simply decide to change her strategy ceasing to supervise and incentivize the

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47 ⁶This finding is related to the result established in MacLeod (2003) in which wage compression occurs when the measures
48 of agent performance are subjective. However, the mechanism behind wage compression in MacLeod (2003) is different from
49 ours. In the previous model, wage compression follows from the fact that subjective evaluations are unverifiable so that the
50 optimization problem of the principal includes the additional constraint that both the agent and the principal truthfully reveal
51 their private signals. Wage compression is also present in the model of influence activities in promotion decisions of Milgrom
52 (1988) in which the reduction in wage differentials between available jobs is found to be an optimal response against influence
53 activities.

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56 ⁷Note that our model does not consider heterogeneity of workers' productivity levels so as to leave aside the problem of
57 adverse selection and focus on moral hazard. Beyer, Guttman and Marinovic (2012) combines moral hazard and adverse
58 selection in the context of performance manipulation.

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9 agent even in a context in which the cost of supervision is arbitrarily low.

10 The rest of the paper is organized as follows. We present our model in Section 2 and study influence and
11 influence-free contracts in Section 3. The analysis of the supervision decision is developed in Section 4. We
12 conclude in Section 5. All proofs are available in the appendix.
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16 2 The Model

17 2.1 Description of Actions and Payoffs

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20 We consider a principal-agent model with three stages described as follows.
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- 23 • In Stage 1, the principal [she] sets a contract \mathbf{w} that will be used to pay the agent [he] in the last stage
24 of the game. The contract is contingent on the level of production in the organization $y \in Y := \{0, 1\}$,
25 which yields revenues $R(y)$ for the principal, where $R(0) < R(1) \leq \bar{R}$. This level of production is a
26 hard and non-manipulable signal of the agent's level of effort.
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29 In Stage 1, the principal also decides whether to engage in supervising the agent ($s = 1$) or not ($s = 0$)
30 in order to obtain the additional signal (v) about the agent's level of effort.⁸ The contract can be made
31 contingent on this supervision signal $v \in V := \{B, G\}$ which costs $\phi_s \geq 0$ to the principal and which
32 is collected in Stage 3. This piece of information can be interpreted as a behavioral signal about the
33 employee's performance where B means: *the agent is a lazy (bad) employee* and G means: *the agent*
34 *is a hard-working (good) employee.*
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- 37 • In Stage 2, the agent decides whether to exert a high level of effort ($e = e_H$) or a low level of effort
38 ($e = e_L$) on a productive task, where $e_H > e_L$. The level of effort (e) exerted by the agent on the
39 productive task affects the level of production in the organization (y). The cost of effort on the
40 productive task is denoted by $\phi(e) \geq 0$. We denote $\phi_e := \phi(e_H) > 0$ and without loss of generality
41 assume that $\phi(e_L) = 0$.
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44 In Stage 2, the agent also decides whether to undertake an influence activity ($a = 1$) or not ($a = 0$).
45 The personal cost for the agent of undertaking influence activities is denoted by $\phi(a) \geq 0$, where
46 $\phi_a := \phi(1) > 0$ and $\phi(0) = 0$. We refer to ϕ_a as private influence costs in the remainder of the paper.
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49 The objective of the influence activity is to affect the evaluation of the principal with regard to the
50 agent's actual level of effort by distorting the principal's perception (v_s) of the supervision signal (v).
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53 ⁸This part of the game resembles models of costly acquisition of additional signals (Lambert, 1985).
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Our model builds on the idea that if the principal engages in supervision in Stage 1 and the agent undertakes influence activities then she will not necessarily observe the true value of the supervision signal v . Instead, the principal will observe v_s which refers to the principal's, possibly erroneous, perception of the true signal. We describe the influence process in detail in Section 2.2.

- In Stage 3, the principal cannot observe the level of effort on the productive task. However, the principal observes the level of production as well as the behavioral signal if the principal decided to supervise the agent. The principal then pays the agent according to the contract chosen in Stage 1. It is assumed that the supervision signal when there is no influence from the agent (i.e. $v_s := v$) satisfies the condition that $P[v = B | e = e_L] = P[v = G | e = e_H] = \rho_v$, where the precision of the behavioral signal is denoted by $\rho_v \in (\frac{1}{2}, 1]$. We assume that if the agent does not undertake the influence activity, then the level of output (y) satisfies the condition that $P[y = 0 | e = e_L] = P[y = 1 | e = e_H] = \rho_y$, where the precision of the hard signal is denoted by $\rho_y \in (\frac{1}{2}, 1]$.

The final payoff for the principal is determined as follows.

$U_P := U(s, v_s, w, y) = R(y) - w_y v_s - s\phi_s$, where $y \in \{0, 1\}$ indicates the level of production and $s \in \{0, 1\}$ denotes whether supervision takes place ($s = 1$) or not ($s = 0$).

The final payoff for the risk-averse agent is determined as follows.

$$U_A := U(a, e, v_s, w) = u(w_y v_s) - \phi(e) - \phi(a) > 0 \text{ where } u' > \varepsilon > 0, u'' < 0.^9$$

We then denote $w_y v_s \in \mathbb{R}$ the wage that is paid to the agent contingently on receiving signals y and v_s . We set the agent's outside option $\bar{u} = 0$.

2.2 Assumptions

First recall that the principal does not directly observe the level of effort of the agent on the productive task, $e \in \{e_L, e_H\}$ but she receives a hard signal on the level of effort by observing output (y). The principal may obtain an additional signal about the performance of her subordinate by engaging in supervision activities at a cost. We assume that the supervisor's perception of the behavioral signal (v_s) can be manipulated by influence activities (a). We model the influence of the agent on his supervisor's assessments as a case of biased attribution (Bénabou and Tirole, 2002) in which the principal may mistakenly perceive a negative signal about her employee as being positive as a result of influence activities. This biased attribution process can be related to the concept of transference for which the characteristic of an agent as a person is associated

⁹We assume that the utility of the agent is separable in effort and in the influence cost as is the case for example in MacLeod (2003).

with his quality as an employee even though in our context “*being a good person*” is not informative about “*being a good employee*” (Mullainathan, Schwartzstein and Schleiffer, 2008).¹⁰ In the following assumption, we refer to $\pi \in [0, 1]$ as the bias of the principal. In line with Bénabou and Tirole (2002), we consider that the principal and the agent are fully aware of the bias of the principal. We state these assumptions as follows.

Assumption I (The influence process)

If the agent decides to undertake an influence activity in Stage 2 ($a = 1$), then the principal will perceive with probability $\pi \in [0, 1]$ any behavioral signal as if it were good.

With probability $(1 - \pi)$ the principal uses standard Bayesian updating.

The bias of the principal $\pi \in [0, 1]$ captures the difficulty of the supervisor to disentangle positive influence behaviors ($a = 1$) from positive behavioral signals ($v = G$). Clearly the existence of this bias creates incentives for the agent to manipulate the behavioral signal through influence activities. Since the principal is aware of her own biases, she knows that perceiving her employee positively ($v_s = G$) may not systematically imply that the behavioral signal was positive given that, with probability π , the principal being under the influence of the agent ($a = 1$) always perceives the behavioral signal positively.

In our model, influence activities are assumed to be costly for the organization as they detract workers from their productive task (Milgrom, 1988; Milgrom and Roberts, 1992). Influence activities are time-consuming and undermine the quality of the work of the agent. This productivity-based influence cost translates into the following assumption in which influence activities reduce the probability that the agent obtains the high level of output for a given level of effort. We refer to productivity-based influence costs as influence costs in the remainder of the paper.

Assumption C (Influence costs and the value of the firm)

If the agent decides to undertake an influence activity ($a = 1$), then $P[y = 1 | e = e_H] = (1 - \alpha)\rho_y$ and $P[y = 1 | e = e_L] = (1 - \alpha)(1 - \rho_y)$ where $\alpha \in [0, 1]$ measures the influence cost.

One important feature of our model concerns the contractibility of the influence activity. We clarify this point in Assumption O.

Assumption O (Observability of actions and signals)

- i) The supervision signal v_s is observable by both the agent and the principal.*
- ii) The influence activity ($a \in \{0, 1\}$) is not observed by the supervisor.*

¹⁰We can also think of trust and positive reciprocity as important factors in explaining the supervisor’s biased perception of the performance of the agent in the presence of influence activities (see Hosmer, 1995).

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9 The first part of Assumption O implies that both the principal and the agent agree on the value of signal
10 v_s so that the supervision signal can be treated as if it were verifiable (see MacLeod, 2003). This is the
11 case if we assume that a third party can design a mechanism that would punish the agent and the principal
12 if they do not reveal the same value of the soft signal v_s . The second part of Assumption O implies that
13 the influence activity is unverifiable by a third party so that the previously mentioned mechanism cannot
14 be applied and incentive contracts cannot be made contingent on the influence activity. These features of
15 our model allow us to disentangle the issues related to the fact that subjective evaluations are unverifiable
16 (MacLeod, 2003) from the issues related to the manipulability of such evaluations.
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23 2.3 Definitions and Properties of Contracts

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25 Next we introduce notations and definitions that will be useful to characterize the contracts derived in
26 Section 3. We denote by $\mathbf{w} = [w_{1G}, w_{1B}, w_{0G}, w_{0B}]$, where $\mathbf{w} \in \mathbb{R}_+^4$, the contract designed by the principal
27 in Stage 1 according to which the agent will be paid as a function of the hard and the behavioral signals.
28 The principal will implement the efficient level of effort e_L or e_H depending on the actual cost of inducing
29 high effort. We denote by $\hat{\mathbf{w}} \in \mathbb{R}_+^4$ the contract that minimizes the cost for the principal of implementing
30 the high level of effort. In Section 3, we characterize this contract in the presence of supervision by showing
31 how wages are affected by an increase in a parameter κ (namely, the principal's bias π or the influence costs
32 α).¹¹
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39 Definition 1 (Respective weights of hard and soft signals)

40 *We say that an increase in a parameter (κ) raises the weight that is assigned to the hard (behavioral)*
41 *signal in the contract if $\frac{\partial}{\partial \kappa} (w_{1B} - w_{0G}) > 0$ ($\frac{\partial}{\partial \kappa} (w_{0G} - w_{1B}) > 0$).*
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44 In the following definition we assess the responsiveness of incentive contracts to hard and behavioral
45 signals. In particular we state that the *power of incentives* associated with a contract increases in a given
46 signal if the difference between wages following a low value of the signal and wages following a high value
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49 ¹¹Our signals satisfy the monotone likelihood ratio property so that the optimal contract is such that $\hat{w}_{1v_s} \geq \hat{w}_{0v_s}$ for any
50 $v_s \in \{B, G\}$ and $\hat{w}_{yG} \geq \hat{w}_{yB}$ for any $y \in \{0, 1\}$. For further details, see Corgnet and Rodriguez-Lara (2012), where we study in
51 detail two special cases of the current model: rational supervision ($\pi = 0$) and private influence costs ($\pi > 0, \alpha = 0$). In both
52 setups, we characterize the optimal contract that implements the high level of effort in the presence as well as in the absence
53 of supervision. Most of our results are in line with previous research such as Holmström (1979), Lambert (1985) and Banker
54 and Datar (1989), showing that the weight assigned to a signal increases in its precision. In addition, we show that as signal
55 precision decreases (as is the case for example when the behavioral signal is more manipulable), the cost of implementing the
56 high level of effort decreases for the principal.
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of the signal increases. In that respect our definition of the *power of incentives* is related to the concept of wage compression since a reduction in the power of incentives in both hard and behavioral signals implies wage compression.

Definition 2 (Wage compression and the power of incentives)

i) We say that the power of incentives increases (decreases) in the hard signal (y) with respect to parameter (κ) whenever $\frac{\partial(w_{1v_s}-w_{0v_s})}{\partial\kappa} > 0$ (< 0) for any $v_s \in \{B, G\}$.

ii) We say that the power of incentives increases (decreases) in the behavioral signal (v_s) with respect to the parameter (κ) whenever $\frac{\partial(w_{yG}-w_{yB})}{\partial\kappa} > 0$ (< 0) for any $y \in \{0, 1\}$.

3 Influence and Influence-free contracts

In this section, we characterize the properties of optimal incentive schemes by assuming that the principal is willing to supervise the agent and induce him to exert high effort in equilibrium.¹² The principal has two different options when designing such schemes. On the one hand, the principal can propose influence contracts for which she anticipates that, in equilibrium, agents will be willing to manipulate the behavioral signal. On the other hand, the principal can deter manipulation attempts by proposing influence-free contracts. We denote $\hat{\mathbf{w}}^I$ [$\hat{\mathbf{w}}^F$] the wage vector that minimizes the cost of implementing the high level of effort $\hat{\mathbf{w}}^I \mathbf{P}^I$ [$\hat{\mathbf{w}}^F \mathbf{P}^F$], where \mathbf{P}^I [\mathbf{P}^F] is the probability vector associated with the case in which the agent exerts a high level of effort on the productive task and the principal tolerates [does not tolerate] influence from the agent.¹³ We will refer to $\hat{\mathbf{w}}^I$ and $\hat{\mathbf{w}}^F$ as the optimal influence and influence-free contracts, respectively.

The principal will design influence-free contracts instead of influence contracts in Stage 1 as long as the following condition is satisfied:

$$\begin{aligned} \alpha \rho_y (R(1) - R(0)) + \hat{\mathbf{w}}^I \mathbf{P}^I &\geq \hat{\mathbf{w}}^F \mathbf{P}^F \Leftrightarrow R(1) \geq R^{F>I} := \frac{\hat{\mathbf{w}}^F \mathbf{P}^F - \hat{\mathbf{w}}^I \mathbf{P}^I}{\alpha \rho_y} + R(0) \\ \Leftrightarrow \alpha &\geq \alpha_f := \frac{\hat{\mathbf{w}}^F \mathbf{P}^F - \hat{\mathbf{w}}^I \mathbf{P}^I}{\rho_y (R(1) - R(0))} \end{aligned} \tag{1}$$

This condition states that it is optimal for the principal to design influence-free contracts as long as the cost of implementing an efficient equilibrium under influence-free contracts is lower than under influence contracts. The cost associated with the use of influence contracts consists of two parts: the reduction in the

¹²We study the principal’s decision to supervise the agent in Section 4, where we also discuss strategies inducing low effort in equilibrium.

¹³For simplicity we assume that wages are row vectors and probabilities are column vectors so as to avoid the use of transposes.

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9 revenues of the firm due to destructive influence activities ($\alpha\rho_y (R(1) - R(0))$) and the payment of wages to
10 the agent ($\mathbf{w}^I \mathbf{P}^I$). It is important to illustrate why, in our context, influence-free contracts may be dominated
11 by influence contracts implying that manipulation attempts can be observed in equilibrium. To that end,
12 we consider the case in which influence activities are effective ($0 < \pi < 1$) but costless ($\alpha = \phi_a = 0$). In that
13 case, the agent will engage in influence activities as long as wages are higher when the principal collects a
14 good behavioral signal rather than a bad one (i.e. $w_{yG} > w_{yB}$). Consequently, influence-free contracts will
15 be such that the behavioral signal is ignored by the principal ($w_{yG} = w_{yB}$) and only the output signal can
16 be used to infer the agent's level of effort. In the case of influence contracts, the principal can use both
17 signals making the pay of the agent contingent on output as well as on the manipulated, though informative,
18 behavioral signal. Note that the behavioral signal continues to be informative for the principal even in
19 the presence of influence activities as long as $\pi < 1$. Following the result of Kim (1995) we conclude that
20 influence-free contracts, which are based on less information, are more costly to implement for the principal
21 than influence contracts in the current example.
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30 31 **3.1 Influence contracts**

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33 If the principal decides to supervise the agent in an efficient equilibrium that induces high effort, she can
34 allow for the influence activity by choosing a contract $\hat{\mathbf{w}}^I = (\hat{w}_{1G}^I, \hat{w}_{1B}^I, \hat{w}_{0G}^I, \hat{w}_{0B}^I)$ that satisfies the condition
35 that the agent will perform the influence activity.¹⁴
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38 **Proposition 1 (Influence contracts and power of incentives)**

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40 *i) The optimal influence contract that implements the efficient level of effort is such that an increase in*
41 *the principal's bias (π) or that a decrease in influence costs (α) raises the weight that is assigned to the hard*
42 *signal.*
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45 *ii) The optimal influence contract that implements the efficient level of effort is such that the power of*
46 *incentives decreases in the behavioral signal (v_s) with respect to the principal's bias (π) whereas the power of*
47 *incentives decreases in the hard signal with respect to influence costs (α).*
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50 *iii) The principal's cost of implementing the efficient level of effort increases in the principal's bias (π)*
51 *and in the influence costs (α).*
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54 This proposition shows that the principal is willing to use the hard signal more intensively relative to the
55 behavioral signal as π increases since the accuracy of the behavioral signal decreases in the principal's bias.
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57 ¹⁴We derive the condition under which the agent who is being supervised performs the influence activity in Lemma 1 in
58 the appendix. We note that for costless influence activities ($\phi_a = 0$) the subset of optimal wages that satisfy the condition is
59 non-empty. In general, there exists an upper bound for influence activities costs for which the condition is satisfied.
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9 Interestingly, the proposition also shows that an increase in influence costs (α) tends to lower the weight
10 that is assigned to the hard and non-manipulable signal (y). This is the case because the accuracy of a
11 low level of output ($y = 0$) as a predictor of the level of effort of the agent decreases as α rises. Indeed, in
12 the presence of influence costs, a low level of production can be attributed either to a low level of effort or
13 to influence activities. This implies that a low output signal is interpreted less negatively in the presence
14 of influence costs, that is $\frac{\partial \hat{w}_{0v_s}^I}{\partial \alpha} > 0$ for any $v_s \in \{B, G\}$.¹⁵ In the extreme case in which influence costs
15 destroy the whole output ($\alpha = 1$) the signal $y = 0$ is uninformative about the level of effort of the agent. As
16 a result, the weight of the hard signal in the agent's wage will be reduced as influence costs increase. Also,
17 applying Definition 2 we know that the power of incentives decreases in the hard signal with respect to α
18 since $\frac{\partial \hat{w}_{0v_s}^I}{\partial \alpha} > 0$ and $\frac{\partial \hat{w}_{1v_s}^I}{\partial \alpha} = 0$ for any $v_s \in \{B, G\}$.

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20 Finally, the proposition shows that the manipulability of the behavioral signal and the magnitude of
21 influence costs tend to increase the principal's cost of implementing the efficient level of effort. This is the
22 case because an increase in π reduces the precision of the behavioral signal while an increase in α reduces
23 the precision of the hard signal. It follows that in the case of influence contracts, the more manipulable is
24 the behavioral signal and the larger are the influence costs, the less effective is supervision as a disciplining
25 device for the agent. This implies that a larger rent will have to be paid to the risk-averse agent in order to
26 ensure that the participation constraint holds.

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28 Our results suggest that the principal would be better-off in an organizational environment in which agents
29 do not have the possibility to influence her assessments. For example, supervisors may limit communication
30 with subordinates to avoid influence activities (Milgrom, 1988; Milgrom and Roberts, 1988). They may
31 also design an organizational structure that limits interpersonal relationships between employees at different
32 levels of the hierarchy. This can be achieved by having employees at different layers of the hierarchy work at
33 different locations as is the case in the increasingly popular virtual organizations. In that case, employees'
34 supervision is performed through computer-mediated communication systems.¹⁶ However, the quality of the
35 supervision signal may be undermined in those cases (Jarvenpaa and Leidner, 1999). The optimal strategy
36 consists for the principal of finding the right balance between getting access to information about the agent's
37 level of effort while avoiding influence activities. An alternative solution to deter influence activities is to
38 design influence-free contracts.

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54 ¹⁵Note that the informativeness of the hard signal $y = 1$ is not affected by α , that is $\frac{\partial \hat{w}_{1v_s}^I}{\partial \alpha} = 0$ for any $v_s \in \{B, G\}$.

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65 ¹⁶A large number of programs such as Spectorsoft, Virtual MonitoringTM, Employee Monitoring or Webwatcher are already
available to monitor employees' activities. An early account of computer-based monitoring systems was considered in Chalykoff
and Kochan (1989).

3.2 Influence-free contracts

The principal needs not accept influence activities from the agent and may design influence-free contracts that deter manipulation attempts. In that case, the principal will supervise the agent but in such a way that the agent never conducts the influence activity. We denote by $\hat{\mathbf{w}}^F = (\hat{w}_{1G}^F, \hat{w}_{1B}^F, \hat{w}_{0G}^F, \hat{w}_{0B}^F)$ the optimal influence-free wage contract that induces a high level of effort in equilibrium in the case of influence costs. In the following proposition we characterize the main properties of the optimal influence-free contract $\hat{\mathbf{w}}^F$, where we denote $\bar{\alpha} = \max\{\alpha_0, \alpha_1, \alpha_f\}$ where $\alpha_0 = \frac{\pi(1-\rho_y)}{(1-\pi)\rho_y}$, $\alpha_1 = \frac{\pi(1-\rho_v)}{(1-\pi)\rho_v + \pi}$ and $\alpha_f = \frac{\hat{\mathbf{w}}^F \mathbf{P}^F - \hat{\mathbf{w}}^I \mathbf{P}^I}{\rho_y(R(1) - R(0))}$.

Proposition 2 (Influence-free contracts and power of incentives)

i) The optimal influence-free contract that implements the efficient level of effort is such that either an increase in the principal's bias (π) or an increase in influence costs (α) raises the weight that is assigned to the hard signal.

ii) The optimal influence-free contract that implements the efficient level of effort is such that the power of incentives decreases in the behavioral signal (v_s) with respect to the principal's bias (π). In addition, for any $\alpha \geq \bar{\alpha}$, the power of incentives increases in the hard signal with respect to influence costs (α). As a result, the variance of wages increases in influence costs (α).

iii) The principal's cost of implementing the efficient level of effort increases in the principal's bias (π) but decreases in the influence costs (α).

Similarly to the case of influence contracts, influence-free contracts are such that the weight assigned to behavioral signals decreases as the manipulability of the signal increases (π). Nonetheless, influence and influence-free contracts differ since an increase in influence costs (α) raises the weight that is assigned to the hard signal in the case of influence-free contracts (Proposition 2i) while the opposite is true in the case of influence contracts (Proposition 1i). The intuition for this result follows from the fact that, under influence-free contracts, the principal uses the hard signal to deter influence activities. The principal increases the opportunity cost of influence activities by increasing the incentives associated with the hard signal. In that case, influence activities become less profitable as they reduce the probability that the agent will get the high payment associated with a high level of performance on the hard signal. Consequently, the principal will increase the weight given to the hard signal so as to discourage influence activities (see Proposition 2i).

The second part of Proposition 2 follows from the fact that for any $\alpha \geq \bar{\alpha}$ the following comparative statics hold $\frac{\partial \hat{w}_{1G}^F}{\partial \alpha} > 0$, $\frac{\partial \hat{w}_{1B}^F}{\partial \alpha} > 0$, $\frac{\partial \hat{w}_{0G}^F}{\partial \alpha} < 0$ and $\frac{\partial \hat{w}_{0B}^F}{\partial \alpha} < 0$. Applying Definition 2, we conclude that, for any $\alpha \geq \bar{\alpha}$, the power of incentives increases in the hard signal with respect to α . Notice that the threshold ($\bar{\alpha}$) above which influence costs lead to an increase in the power of incentives increases in the principal's bias

(π). This occurs because for high values of π we obtain that $\frac{\partial \hat{w}^F}{\partial \alpha} \leq 0$ in which case the power of incentives does not increase in the hard signal with regard to influence costs. For large values of π the principal's mind is more manipulable and influence activities are more appealing to agents. As a result, eliminating influence activities may require decreasing the pay associated with the good behavioral signal ($\frac{\partial \hat{w}_{yG}^F}{\partial \alpha} < 0$ for any $y \in \{0, 1\}$) in addition to increasing the pay associated with a high level of output ($\frac{\partial \hat{w}_{1v_s}^F}{\partial \alpha} > 0$ for any $v_s \in \{B, G\}$). If the former effect dominates the latter then $\frac{\partial \hat{w}_{1G}^F}{\partial \alpha} \leq 0$.

The main implication of Proposition 2 is that influence-free contracts may significantly differ from influence contracts with regard to the weight given to hard and behavioral signals. This finding suggests that in the presence of influence costs workers with different levels of productivity may be offered different types of contracts.¹⁷ We elaborate on this conjecture in the next proposition by showing that high-powered incentives and influence-free contracts are more likely to be offered to agents for which influence is especially costly in terms of firm productivity.

Proposition 3 *If influence costs satisfy the condition that $\alpha \geq \bar{\alpha}$, then the wages offered to low-productivity agents ($R(1) < R^{F>I}$) are less responsive to the hard signal than they are for high-productivity agents ($R(1) \geq R^{F>I}$).*

This result follows from condition (1) according to which high-productivity workers ($R(1) \geq R^{F>I}$) will be offered influence-free contracts whereas low-productivity agents ($R(1) < R^{F>I}$) will be offered contracts under which it is optimal for the agents to influence the principal's perception of the behavioral signal. This result is in line with the main findings in Green (1998) that studies the impact of skills on wages. Green (1998) finds that computer skills (i.e., hard signals) are highly valued whereas communication skills (i.e., behavioral signals) have little impact on wages, so that workers at higher levels of the hierarchy receive wages that are more responsive to the hard signal than to behavioral signals. More generally, our findings suggest that top executives whose impact on firm value is supposedly high are more likely to be paid according to hard signals than employees at lower levels of the hierarchy.

4 Supervision Decision

A principal who suffers from cognitive bias in the perception of the behavioral signal ($\pi > 0$) may decide not to supervise the agent so as to avoid manipulation attempts. This may be beneficial for the firm when influence costs are particularly high. Arguably, the behavioral signal may include additional information

¹⁷Although we refer to different productivity levels, we should acknowledge that our model leaves aside the problem of adverse selection while focusing on moral hazard; i.e., we do not consider different types of agents in our setup.

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9 on the agent level of effort that the principal may need in order to incentivate the agent to exert a high
10 level of effort. This is the case because, with more information available, the principal is more likely to
11 detect possible shirking behaviors of her subordinate. The decision of supervising the agent or not will be
12 determined by comparing the informative value of the behavioral signal and its cost, which includes the
13 influence costs (α) and the cost of acquiring the signal (ϕ_s).¹⁸ Our main result in this section (Proposition
14 4) states that the principal may decide not to supervise the agent, even if the cost of collecting the behavioral
15 signal is arbitrarily low.

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17 To analyze whether supervision is optimal from the point of view of the principal, we will have to ensure
18 that implementing the high level of effort in an equilibrium with supervision is preferred to implementing
19 the low level of effort. That is, we will not assume as was the case in the previous section that the high
20 level of effort is efficient. We establish conditions under which it is optimal for the principal to supervise the
21 agent by describing the conditions under which each of the following four types of equilibria exist:

22 N_L) The principal does not supervise the agent and the latter exerts low effort.

23 N_H) The principal does not supervise the agent and the latter exerts high effort.

24 F) The principal supervises the agent and uses influence-free contracts to induce high effort.

25 I) The principal supervises the agent and uses influence contracts to induce high effort.

26 We compare all strategies inducing a high level of effort in equilibrium (N_H , F and I) with the strategy
27 in which the principal implements the low level of effort (N_L). That is, we derive individual rationality
28 constraints for the principal in each of these three cases. Strategy N_H , F and I are respectively preferred
29 to the implementation of the low effort equilibrium (N_L) if the following conditions are satisfied:¹⁹

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$$R(1) \geq \frac{\hat{\mathbf{w}}^{N_H} \mathbf{P}^{N_H} - \bar{u}}{2\rho_y - 1} + R(0) := R^{N_H} \quad (2N_H)$$

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$$R(1) \geq \frac{\phi_s + \hat{\mathbf{w}}^F \mathbf{P}^F - \bar{u}}{2\rho_y - 1} + R(0) := R^F \quad (2F)$$

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$$R(1) \geq \frac{\phi_s + \hat{\mathbf{w}}^I \mathbf{P}^I - \bar{u}}{2\rho_y - 1 - \alpha\rho_y} + R(0) := R^I \quad (2I)$$

51 We know from the previous section that the cost of implementing high effort increases in α in the
52 case of influence contracts while it decreases in α in the case of influence-free contracts. This implies that
53 $\frac{\partial R^I}{\partial \alpha} > 0$ and $\frac{\partial R^F}{\partial \alpha} < 0$. It also follows directly from condition (2N_H) that $\frac{\partial R^{N_H}}{\partial \alpha} = 0$ and it follows from
54 conditions (2F) and (2I) that $\frac{\partial R^I}{\partial \phi_s} > 0$ and $\frac{\partial R^F}{\partial \phi_s} > 0$. Using these properties along with the threshold
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56 ¹⁸In order to leave aside the uninteresting case in which the principal supervises the agent without inducing high effort, we
57 assume that supervision costs (ϕ_s) are strictly positive.

58 ¹⁹Condition (2I) holds as long as $2\rho_y - 1 - \alpha\rho_y \neq 0$.

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9 $R^{F>I} := \frac{\hat{\mathbf{w}}^F \mathbf{P}^F - \hat{\mathbf{w}}^I \mathbf{P}^I}{\alpha \rho_y} + R(0)$ defined in condition (1) in Section 3.1, we can represent graphically the
10 equilibrium strategy that applies for a given set of values of $R(1)$ and α . Note that $\frac{\partial R^{F>I}}{\partial \alpha} > 0$ because
11 $\hat{\mathbf{w}}^I \mathbf{P}^I$ is increasing in α while $\hat{\mathbf{w}}^F \mathbf{P}^F$ is decreasing in α (Propositions 1iii and 2iii). That is, influence-free
12 contracts will be more likely to arise in equilibrium as influence costs increase (see Figure 1 below).
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15 In Figure 1, we represent the case in which the cost of supervision (ϕ_s) is arbitrarily low. We also consider
16 the situation in which influence contracts are preferred to influence contracts for $\alpha = 0$. This condition holds
17 as long as $\hat{\mathbf{w}}^I \mathbf{P}^I < \hat{\mathbf{w}}^F \mathbf{P}^F$ which will be the case for example if influence activities do not entail private
18 costs for the the agent ($\phi_a = 0$). If this condition does not hold, the only two possible equilibrium strategies
19 will be either to supervise the agent using influence-free contracts or not to supervise the agent inducing a
20 low level of effort in equilibrium.
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24 Figure 1 around here

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26 In the case in which supervision costs are high, the principal will not supervise the agent and will simply
27 choose between inducing the agent to exert high effort (N_H) or not (N_L). The former strategy will be chosen
28 whenever the gains from high effort ($R(1)$) are large enough.
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31 In the following proposition we show that, even if supervision costs are arbitrarily low, the principal may
32 decide to avoid supervision. Given that supervision costs are arbitrarily low, we are in the case illustrated in
33 Figure 1 in which only three equilibrium strategies are possible: N_L , F or I . In that context, let us consider
34 the situation in which influence activities are absent because the principal is not manipulable ($\pi = 0$). In
35 that case, we know that the principal will decide to supervise the agent since it is costless to do so and no
36 influence activities will be initiated in equilibrium. Now consider an increase in the principal's bias. From
37 Propositions 1iii and 2iii, we know that the principal's cost of implementing the high level of effort increases
38 in π so that the thresholds R^F and R^I also increase in π . This implies that for sufficiently high levels of the
39 principal's bias none of conditions (2F) and (2I) are likely to hold in which case the principal will prefer
40 not to supervise the agent and induce him to exert low effort rather than supervising and incentivizing the
41 agent.
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49 We denote by π^- the level of the principal's bias such that the principal is indifferent between supervising
50 the agent and inducing him to exert high effort and not supervising the agent without incentivizing him.
51 Formally, π^- is defined, as the level of bias such that:
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$$55 R(1) = \min \{R^F, R^I\} \tag{3}$$

56 Note that there always exists an interior solution $\pi^- \in (0, 1)$ for equation (3). From the proofs of Proposi-
57 tion 1iii and 2iii (see appendix) we know that $\frac{\partial \hat{\mathbf{w}}^F \mathbf{P}^F}{\partial \rho_y} < 0$ and $\frac{\partial \hat{\mathbf{w}}^I \mathbf{P}^I}{\partial \rho_y} < 0$ which implies that $\frac{\partial \min\{R^F, R^I\}}{\partial \rho_y} < 0$.
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Also, $\lim_{\rho_y \rightarrow 1} \min \{R^F, R^I\} = \phi_s$ so that for ϕ_s arbitrarily low we have: $R(1) > \lim_{\rho_y \rightarrow 1} \min \{R^F, R^I\}$. As a result, for a given $\pi^- \in (0, 1)$, there exists $\rho_y^- \in \left(\frac{1}{2-\alpha}, 1\right)$ such that equation (3) is satisfied as long as $R(1) < \lim_{\rho_y \rightarrow \frac{1}{2-\alpha}} \min \{R^F, R^I\}$ where $\lim_{\rho_y \rightarrow \frac{1}{2-\alpha}} \min \{R^F, R^I\} = \frac{2-\alpha}{\alpha} (\phi_s + \hat{\mathbf{w}}^F \mathbf{P}^F - \bar{u}) + R(0)$. There exists a range of values $\alpha \in (0, \alpha^-)$ for which this condition holds since $\lim_{\alpha \rightarrow 0} \frac{2-\alpha}{\alpha} (\phi_s + \hat{\mathbf{w}}^F \mathbf{P}^F - \bar{u}) + R(0) = \infty$ and $\frac{\partial \frac{2-\alpha}{\alpha} (\phi_s + \hat{\mathbf{w}}^F \mathbf{P}^F - \bar{u})}{\partial \alpha} < 0$.

Proposition 4 *Given ρ_y^- and $\alpha \in (0, \alpha^-)$, the principal will not be willing to supervise the agent for any level of the bias above π^- , even though the cost of supervision is arbitrarily low.*

Supervising the agent to collect additional signals is crucial for the principal's ability to implement the high level of effort. In case the principal's bias increases, the precision of the behavioral signal obtained through supervision is undermined. This forces the principal to increase wages to compensate the agent for the increase in the variance of wages which follows from the use of a more noisy behavioral signal. If the principal's bias is particularly severe (above π^-), the principal may simply decide to change her strategy ceasing to supervise the agent and inducing him to exert low effort.

5 Conclusion

In this paper, we analyzed the design of incentive contracts in a principal-agent model in which the agent had the possibility to engage in influence activities and manipulate a behavioral signal which was collected by the principal in the supervision process. We found that an increase in the manipulability of the behavioral signal increases information asymmetry between the agent and the principal and increases the cost of implementing the efficient level of effort as a result. Also, we showed that an increase in the manipulability of the behavioral signal raises the weight assigned to the non-manipulable hard signal and decreases the power of incentives associated with the behavioral signal whether the principal designs influence or influence-free contracts.

Interestingly, we identified fundamental differences between influence and influence-free contracts regarding the effect of an increase in influence costs. In particular, the weight assigned to the hard signal decreases in the influence costs in the case of influence contracts while the opposite is true in the case of influence-free contracts. This result holds because the principal who designs influence-free contracts aims at deterring influence activities by increasing their opportunity cost which is achieved by raising the incentives associated with the hard signal. More specifically, we show that high-powered incentives and influence-free contracts are more likely to be assigned to agents for which influence is especially costly in terms of firm productivity. This result is in line with empirical findings in Green (1998) showing that workers at higher levels of the hierarchy

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receive wages that are more responsive to the computer-based hard signal than to the communication-based behavioral signal (see also Liberti and Mian 2009).

Finally, we showed that the principal may intentionally avoid supervising the agent when the manipulability of the behavioral signal is high. This result holds even if the cost of supervision is arbitrarily low. This is the case because inducing high effort may become unsustainable for the principal as the manipulability and thus the noisiness of the behavioral signal increases.

Although our model provides a generalization of the principal-agent model for the case in which some signals are manipulable, we deliberately abstract away from the interesting case of multi-agent frameworks. However, in their definition of influence activities, Milgrom and Roberts (1992) envisage not only personal attempts to manipulate the principal's view of oneself but also the time devoted by organizational members to countervail the manipulation attempts of their coworkers. In order to apprehend influence activities at the organizational level, extending our analysis to the case of multi-agent models with team production and hierarchies may be a fruitful area for future research.

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6 Appendix

Lema 1 The agent who is supervised in an equilibrium that implements the high level of effort performs the influence activity if the following condition is satisfied.

$$(IA) \quad (1 - \alpha)\rho_y [u(w_{1G}^I) - u(w_{1B}^I)] + ((1 - \rho_y) + \alpha\rho_y)[u(w_{0G}^I) - u(w_{0B}^I)] > \frac{\phi_a}{\pi((1 - \rho_y) + \alpha\rho_y)}$$

Proof of Lema 1. We denote $\mathbf{w}^I = [w_{1,G}^I, w_{1,B}^I, w_{0,G}^I, w_{0,B}^I]$ the vector of contingent wages that characterize the influence contracts. We also denote \mathbf{P}_1^I [\mathbf{P}_0^I] the probability of receiving each of these payments when exerting a high [low] level of effort. In the case of influence contracts, the principal allows the agent to engage in influence activities, paying the wages \mathbf{w}^I with probability \mathbf{P}_1^I .

$$\mathbf{P}_1^I := (p_{i1}^I)_{i \in \{1, \dots, 4\}} = \begin{bmatrix} (1 - \alpha)\rho_y(\rho_v + \pi(1 - \rho_v)) \\ (1 - \alpha)\rho_y(1 - \pi)(1 - \rho_v) \\ (1 - (1 - \alpha)\rho_y)(\rho_v + \pi(1 - \rho_v)) \\ (1 - (1 - \alpha)\rho_y)(1 - \pi)(1 - \rho_v) \end{bmatrix}$$

If the agent does not undertake the influence activity, then the probability of receiving these wages is given by:

$$\mathbf{P}_1 = (p_{i1})_{i \in \{1, \dots, 4\}} = \begin{bmatrix} (1 - \alpha)\rho_y\rho_v \\ (1 - \alpha)\rho_y(1 - \rho_v) \\ (1 - (1 - \alpha)\rho_y)\rho_v \\ (1 - (1 - \alpha)\rho_y)(1 - \rho_v) \end{bmatrix}$$

Therefore, the agent undertakes the influence activity if and only if

$$u(\mathbf{w}^I)(\mathbf{P}_1^I - \mathbf{P}_1) > \phi_a.$$

That is,

$$(IA) \quad (1 - \alpha)\rho_y [u(w_{1G}^I) - u(w_{1B}^I)] + ((1 - \rho_y) + \alpha\rho_y)[u(w_{0G}^I) - u(w_{0B}^I)] > \frac{\phi_a}{\pi((1 - \rho_y) + \alpha\rho_y)}$$

This condition states that the agent will undertake the influence activity as long as the benefits derived from increasing the probability of receiving a high pay w_{yG} instead of getting a low pay w_{yB} (where $w_{yB} < w_{yG}$ for any $y \in \{0, 1\}$) are larger than the cost of the influence activity (ϕ_a). We can see in condition (IA) that as the quality of the hard signal (ρ_y) rises, the incentives for the agent to undertake the influence activity decrease. This occurs because as ρ_y increases, the distortion of the soft signal which is achieved through influence activities becomes less effective. For example, the soft signal will be ignored by the principal if the hard signal is perfectly accurate ($\rho_y = 1$ and $\alpha = 0$). Finally, notice that an increase in the principal's bias (π) facilitates influence activities as it lowers the right-hand side in condition (IA). The intuitive reasoning is that an increase in π raises the manipulability of the soft signal so that the probability with which influence activities turn a low pay (w_{yB}) into a high pay (w_{yG}) increases as well. ■

Proof of Proposition 1. We defined \mathbf{P}_1^I above and

$$\mathbf{P}_0^I := (p_{i0}^I)_{i \in \{1, \dots, 4\}} = \begin{bmatrix} (1-\alpha)(1-\rho_y)(1-\rho_v+\pi\rho_v) \\ (1-\alpha)(1-\rho_y)\rho_v(1-\pi) \\ (\alpha+(1-\alpha)\rho_y)(1-\rho_v+\pi\rho_v) \\ (\alpha+(1-\alpha)\rho_y)\rho_v(1-\pi) \end{bmatrix}$$

We can derive the optimal contract under influence ($\hat{\mathbf{w}}^I$) which solves:

$$\begin{cases} (1) \hat{\mathbf{w}}^I = \min_{\mathbf{w} \in \mathbb{R}^4} \mathbf{w} \mathbf{P}_1^I \\ (2) \mathbf{u}(\mathbf{w}) \mathbf{P}_1^I - \phi_e \geq 0 \quad \mathbf{IR} \\ (3) \mathbf{u}(\mathbf{w}) \mathbf{P}_1^I - \phi_e \geq \mathbf{u}(\mathbf{w}) \mathbf{P}_0^I \quad \mathbf{IC} \end{cases}$$

We first define $u_{1G} = u(w_{1G}^I)$, $u_{1B} = u(w_{1B}^I)$, $u_{0G} = u(w_{0G}^I)$ and $u_{0B} = u(w_{0B}^I)$ so that $w_{1G}^I = h(u_{1G})$, $w_{1B}^I = h(u_{1B})$, $w_{0G}^I = h(u_{0G})$ and $w_{0B}^I = h(u_{0B})$ to ensure that the optimization program is concave (see Laffont and Martimort 2002). Then, the first-order Kuhn-Tucker conditions are necessary and sufficient to determine the optimal influence contract.

$$\begin{cases} (1) \hat{\mathbf{w}}^I = \min_{\{u_0, u_1\}} p_{11}^I h(u_{1G}) + p_{21}^I h(u_{1B}) + p_{31}^I h(u_{0G}) + p_{41}^I h(u_{0B}) \\ (2) p_{11}^I u_{1G} + p_{21}^I u_{1B} + p_{31}^I u_{0G} + p_{41}^I u_{0B} - \phi_e \geq 0 \quad \mathbf{IR} \\ (3) p_{11}^I u_{1G} + p_{21}^I u_{1B} + p_{31}^I u_{0G} + p_{41}^I u_{0B} - \phi_e \geq \\ p_{10}^I u_{1G} + p_{20}^I u_{1B} + p_{30}^I u_{0G} + p_{40}^I u_{0B} \quad \mathbf{IC} \end{cases}$$

We denote λ and μ the non-negative Lagrange multipliers associated respectively with the incentive compatibility (**IC**) constraint and the individual rationality (**IR**) constraint.²⁰

The optimal influence contract satisfies that:

$$\begin{cases} (1_{1G}) \quad u'(\hat{w}_{1G}^I) = \frac{\rho_y(\rho_v+\pi(1-\rho_v))}{\lambda\rho_y(\rho_v+\pi(1-\rho_v))+\mu[(1-\pi)(\rho_v-\rho_y)-1]} \\ (1_{1B}) \quad u'(\hat{w}_{1B}^I) = \frac{\rho_y(1-\rho_v)}{\lambda\rho_y(1-\rho_v)-\mu(\rho_v-\rho_y)} \\ (1_{0G}) \quad u'(\hat{w}_{0G}^I) = \frac{(1-(1-\alpha)\rho_y)[\rho_v+\pi(1-\rho_v)]}{\lambda(1-(1-\alpha)\rho_y)[\rho_v+\pi(1-\rho_v)]+\mu(\pi-\alpha)+\alpha(\rho_v-\rho_y)+(1-\pi(1+\alpha))(\rho_v-\rho_y)} \\ (1_{0B}) \quad u'(\hat{w}_{0B}^I) = \frac{(1-(1-\alpha)\rho_y)(1-\rho_v)}{\lambda(1-(1-\alpha)\rho_y)(1-\rho_v)+\mu[(\rho_v+\rho_y+\alpha(\rho_v-\rho_y)-1)]} \end{cases}$$

In order to investigate the properties that are satisfied by the optimal influence contract $\hat{\mathbf{w}}^I = [\hat{w}_{1G}^I, \hat{w}_{1B}^I, \hat{w}_{0G}^I, \hat{w}_{0B}^I]$,

we use the implicit function theorem in equations (1_{1G}), (1_{1B}), (1_{0G}) and (1_{0B}). We obtain that,

$$\begin{cases} \frac{\partial \hat{w}_{0G}^I}{\partial \pi} = \frac{-(2\rho_v-1)((1-\alpha)\rho_y-1)(1-\alpha)\rho_y\mu}{u''(\hat{w}_{0B}^I)((\pi(\rho_v-1)-\rho_v)(1-(1-\alpha)\rho_y)\lambda-\mu((1-\alpha)\rho_y-\rho_v+\pi((1-\alpha)\rho_y+\rho_v-1)))^2} < 0 \\ \frac{\partial \hat{w}_{0G}^I}{\partial \alpha} = \frac{(2\rho_v-1)((1+\rho_v(\pi-1))(\pi(\rho_v-1)\rho_v)\mu}{u''(\hat{w}_{0B}^I)((\pi(\rho_v-1)-\rho_v)(1-(1-\alpha)\rho_y)\lambda-\mu((1-\alpha)\rho_y-\rho_v+\pi((1-\alpha)\rho_y+\rho_v-1)))^2} > 0 \end{cases}$$

whereas

$$\frac{\partial \hat{w}_{1B}^I}{\partial \pi} = \frac{\partial \hat{w}_{1B}^I}{\partial \alpha} = 0$$

²⁰We do not present the feasibility and Slackness conditions for simplicity. We find that in equilibrium $\mu > 0$ and $\lambda > 0$ so (IC) and (IR) are binding constraints (see Corgnet and Rodriguez-Lara 2012). MacLeod (2003) and Holmström (1979) find exactly the same result. Hereafter, we focus on the case of $\mu > 0$ and $\lambda > 0$.

As a result, we conclude that the optimal influence contract that implements the efficient equilibrium satisfies the condition that an increase in either the principal's bias (π) or the productivity-based influence costs (α) raise the weight that is assigned to the hard signal (Proposition 1i). Using the implicit function theorem we can also conclude that the power of incentives decreases in the soft signal (v_s) with respect to the principal's bias (π) and the the power of incentives decreases in the hard signal (y) with respect to productivity-based influence costs (α) (Proposition 1ii). This is the case because $\frac{\partial \hat{w}_{1G}^I}{\partial \pi} < 0$, $\frac{\partial \hat{w}_{1G}^I}{\partial \alpha} = 0$ and $\frac{\partial \hat{w}_{0B}^I}{\partial \pi} = 0$, $\frac{\partial \hat{w}_{0B}^I}{\partial \alpha} > 0$.

To demonstrate part iii) of the proposition, we use the result established by Kim (1995), showing that an information structure \mathbf{P} is more efficient than an information structure $\mathbf{\Pi}$ if its likelihood ratio is a mean preserving spread of that of $\mathbf{\Pi}$.

We compute the following function:

$$\Phi(\rho_v^p, \rho_v^\pi, \rho_y^p, \rho_y^\pi, \pi) := \sum_{i \in S} \left(\frac{p_{i0}^I}{p_{i1}^I} - \frac{p_{i0}}{p_{i1}} \right)$$

Where ρ_i^j stands for the precision of signal $i \in \{v, y\}$ of information structure $j \in \{\mathbf{P}, \mathbf{\Pi}\}$ and $\Pi := \mathbf{P}^I$ denotes the probability vector under influence.

$$\Phi(\rho_v, \rho_v, \rho_y, \rho_y, \pi) = \left(\frac{(1-(1-\alpha)\rho_y)(1-\rho_v+\pi\rho_v)}{(1-\alpha)\rho_y[\rho_v+\pi(1-\rho_v)]} + \frac{(1-\alpha)\rho_y(1-\rho_v+\pi\rho_v)}{(1-(1-\alpha)\rho_y)[\rho_v+\pi(1-\rho_v)]} \right) - \left(\frac{(1-(1-\alpha)\rho_y)(1-\rho_v)}{(1-\alpha)\rho_y\rho_v} + \frac{(1-\alpha)\rho_y(1-\rho_v)}{(1-(1-\alpha)\rho_y)\rho_v} \right) > 0$$

Since $\frac{\partial \left(\frac{(1-(1-\alpha)\rho_y)(1-\rho_v+\pi\rho_v)}{(1-\alpha)\rho_y[\rho_v+\pi(1-\rho_v)]} + \frac{(1-\alpha)\rho_y(1-\rho_v+\pi\rho_v)}{(1-(1-\alpha)\rho_y)[\rho_v+\pi(1-\rho_v)]} \right)}{\partial \pi} > 0$. At the same time, we have that:

$$\frac{\partial \left(\frac{(1-(1-\alpha)\rho_y)(1-\rho_v)}{(1-\alpha)\rho_y\rho_v} + \frac{(1-\alpha)\rho_y(1-\rho_v)}{(1-(1-\alpha)\rho_y)\rho_v} \right)}{\partial \rho_v} < 0.$$

As a result, for any increase in the influence parameter from π^- to π^+ the information structure $\mathbf{P}(\rho_v)$ is not as efficient as $\mathbf{\Pi}(\pi^+, \rho_v)$ since then $\Phi > 0$. In order to make $\mathbf{\Pi}(\pi^+, \rho_v)$ as efficient as \mathbf{P} we can consider the information structure $\mathbf{P}(\rho_v^-)$ where $\rho_v^- < \rho_v$ so that $\Phi(\rho_v^-, \rho_v, \rho_y, \rho_y, \pi^+) = 0$. As a result any increase in π reduces the efficiency of the information structure $\mathbf{\Pi}$.

These results show that an increase in the manipulability of the supervision signal reduces its informativeness implying that the cost of implementing the efficient equilibrium increases with the bias of the principal in the case of influence activities compared to the case of rational supervision. Also, an increase in the precision of the soft signal decreases the cost of implementing the efficient equilibrium more significantly in the case of rational supervision than in the case of influence. This is the case, since under influence an increase in the precision of the supervision signal is partially offset by the fact that it can be distorted by the subordinate. Finally, in the presence of influence activities an increase in the precision of the hard signal tends to compensate for the low accuracy of the soft signal. In the extreme case in which the hard signal is

perfectly informative ($\rho_y = 1$) the principal can infer the level of effort of the agent whether the soft signal is manipulable or not.

The same reasoning applies with respect to the *productivity-based* influence costs α . In particular, an increase in α reduces the precision of the hard signal (y) leading to a less efficient information structure. Using the result of Kim (1995), this implies that an increase in α will increase the cost of implementing the high level of effort.

It is also the case that applying the same reasoning to the precision of the hard signal ρ_y we can show that implement the high level of effort is less costly as ρ_y increases. This is the case since:

$$\frac{\partial \left(\frac{(1-(1-\alpha)\rho_y)(1-\rho_v+\pi\rho_v)}{(1-\alpha)\rho_y[\rho_v+\pi(1-\rho_v)]} + \frac{(1-\alpha)\rho_y(1-\rho_v+\pi\rho_v)}{(1-(1-\alpha)\rho_y)[\rho_v+\pi(1-\rho_v)]} \right)}{\partial \rho_y} < 0. \quad \blacksquare$$

Proof of Proposition 2. We denote $\mathbf{w}^F = [w_{1,G}^F, w_{1,B}^F, w_{0,G}^F, w_{0,B}^F]$ the vector of contingent wages that characterize the influence contracts. We also denote \mathbf{P}_1^F [\mathbf{P}_0^F] the probability of receiving each of these payments when exerting a high [low] level of effort.

We need to solve the following optimization problem.

$$\left\{ \begin{array}{ll} (1) \hat{\mathbf{w}}^F = \min_{\mathbf{w} \in \mathbb{R}^4} \mathbf{w} \mathbf{P}_1^F & \\ (2) \mathbf{u}(\mathbf{w}^F) \mathbf{P}_1^F - \phi_e \geq \bar{u} & \mathbf{IR} \\ (3) \mathbf{u}(\mathbf{w}^F) \mathbf{P}_1^F - \phi_e \geq \mathbf{u}(\mathbf{w}^F) \mathbf{P}_0^F & \mathbf{IC} \\ (4) \mathbf{u}(\mathbf{w}^F) \mathbf{P}_1^F \geq \mathbf{u}(\mathbf{w}^F) \mathbf{P}_1^I & \mathbf{IF} \end{array} \right.$$

We obtain the following first order conditions, where δ is the non-negative Lagrange multiplier associated with restriction **IF**. We can see that $\lambda > 0$, $\mu > 0$ and $\delta > 0$.

$$\left\{ \begin{array}{l} (1_{1G}) \quad u'(\hat{w}_{1G}^F) = \frac{\rho_y \rho_v}{\lambda \rho_y \rho_v + \mu(\rho_y + \rho_v - 1) + \delta(\rho_y \rho_v - (1-\alpha)\rho_y \rho_v - \pi(1-\alpha)\rho_y(1-\rho_v))} \\ (1_{1B}) \quad u'(\hat{w}_{1B}^F) = \frac{(1-\rho_v)\rho_y}{\lambda(1-\rho_v)\rho_y + \mu(\rho_y - \rho_v) + \delta\rho_y(1-\rho_v)(1-(1-\alpha)(1-\pi))} \\ (1_{0G}) \quad u'(\hat{w}_{0G}^F) = \frac{(1-\rho_y)\rho_v}{\lambda(1-\rho_y)\rho_v + \mu(\rho_v - \rho_y) + \delta((1-\rho_y)\rho_v - (1-(1-\alpha)\rho_y)(\rho_v + \pi(1-\rho_v)))} \\ (1_{0B}) \quad u'(\hat{w}_{0B}^F) = \frac{(1-\rho_y)(1-\rho_v)}{\lambda(1-\rho_y)(1-\rho_v) + \mu(1-\rho_y - \rho_v) + \delta(1-\rho_v)(1-\rho_y - (1-(1-\alpha)\rho_y)(1-\pi))} \end{array} \right.$$

If we use the implicit function theorem in these equations we can see that:

$$\left\{ \begin{array}{l} (1_{1G}) \quad \frac{\partial \hat{w}_{1G}^F}{\partial \pi} = -\frac{(\rho_v - 1)\rho_v \rho_y^2 (\alpha - 1)\delta}{u''(\hat{w}_{1G}^F)(\pi(\rho_v - 1)\rho_y(\alpha - 1)\delta + \rho_v \rho_y(\lambda + \alpha\delta) + (\rho_y + \rho_v - 1)\mu)^2} < 0 \\ (1_{1B}) \quad \frac{\partial \hat{w}_{1B}^F}{\partial \pi} = -\frac{(\rho_v - 1)^2 \rho_y^2 (\alpha - 1)\delta}{u''(\hat{w}_{1B}^F)(\pi(\alpha - 1)\delta - \alpha\delta - \lambda)(\rho_v - 1)\rho_y + \mu(\rho_v - \rho_y))^2} > 0 \\ (1_{0G}) \quad \frac{\partial \hat{w}_{0G}^F}{\partial \pi} = -\frac{(\rho_v - 1)\rho_v(1-\rho_y)^2(1+\rho_y(\alpha-1))\delta}{u''(\hat{w}_{0G}^F)(\pi(\rho_v - 1)(1+\rho_v(1-\alpha))\delta - \rho_v\mu + \rho_v(\lambda - \rho_y(\alpha\delta + \lambda) + \mu))^2} < 0 \\ (1_{0B}) \quad \frac{\partial \hat{w}_{0B}^F}{\partial \pi} = -\frac{(\rho_v - 1)^2(\rho_y - 1)((\rho_y(\alpha - 1) + 1))\delta}{u''(\hat{w}_{0B}^F)((\rho_v - 1)(\pi(1 + \rho_y(\alpha - 1))\delta + \lambda - \rho_v(\alpha\delta + \lambda)) + \mu(\rho_v + \rho_y - 1))^2} > 0 \end{array} \right.$$

Similarly, we conclude after some algebraic manipulations that:

$$\left\{ \begin{array}{l} (1_{1G}) \frac{\partial \hat{w}_{1G}^F}{\partial \alpha} > 0 \text{ for } \alpha > \alpha_1, \text{ where } \alpha_1 = \frac{\pi(1-\rho_y)}{(1-\pi)\rho_y + \pi}. \\ (1_{1B}) \frac{\partial \hat{w}_{1B}^F}{\partial \alpha} > 0 \text{ for any } \alpha > 0. \\ (1_{0G}) \frac{\partial \hat{w}_{0G}^F}{\partial \alpha} < 0 \text{ for any } \alpha > 0. \\ (1_{0B}) \frac{\partial \hat{w}_{0B}^F}{\partial \alpha} < 0 \text{ for any } \alpha > \alpha_0, \text{ where } \alpha_0 = \frac{\pi(1-\rho_y)}{(1-\pi)\rho_y}. \end{array} \right.$$

Regarding the variance of wages (see Propositions 2ii) one can see the wage scheme as a mixed Bernoulli distribution with parameter ζ so that the variance of wages $\sigma^2(w)$ in that case is such that: $\sigma^2(w) = \zeta \sigma^2(B_G) + (1 - \zeta) \sigma^2(B_B) + \zeta(1 - \zeta) [E(B_G) - E(B_B)]^2$ where $B_G [B_B]$ is the Bernoulli distribution that takes values w_{1G} and w_{1B} [w_{0G} and w_{0B}] with probability ρ_y and $(1 - \rho_y)$ respectively. To show that $\sigma^2(w)$ increases in α we are left to demonstrate that $\frac{\partial}{\partial \alpha} [E(B_G) - E(B_B)] \geq 0$, that is to show that $\rho_y (w_{1G} - w_{1B}) + (1 - \rho_y) (w_{0G} - w_{0B})$ is increasing in α . We know that as α increases the (IF) constraint is relaxed since costs of influence increase for the agent and at the same time the power of incentives in the hard signal increases in α as we have shown in the previous proposition. As a result, for (IF) to be binding in equilibrium (it has to be the case since $\delta > 0$) it has to be that the benefits associated with influence rise to compensate an increase in costs associated with the influence activity previously mentioned. That is, the power of incentives in the soft signal has to increase with regard to α . This implies that both $(w_{1G} - w_{1B})$ and $(w_{0G} - w_{0B})$ cannot decrease in α . This completes the proof that $\sigma^2(w)$ is increasing in α . Propositions 2i and 2ii follow directly from these results.

To demonstrate part iii) of the proposition note that assessing the principal's cost to implement the efficient level of effort in the case of influence-free contracts crucially hinges on the influence-free constraint (IF) . Indeed, in the case of influence-free contracts neither π nor α affect the precision of the signals received by the principal in equilibrium. As a result, any effect π and α on the cost of implementing the efficient level of effort results from the effect of these parameters on the influence-free constraint. This is what we study next. Let us start by denoting $IF = \mathbf{u}(\mathbf{w}^F) (\mathbf{P}_1^F - \mathbf{P}_1^I)$. Using simple algebra we can establish the following comparative statics for IF : $\frac{\partial IF}{\partial \alpha} > 0$ and $\frac{\partial IF}{\partial \pi} < 0$. It follows from these comparative statics that an increase in α or decrease in π will facilitate the implementation of influence-free contracts and then lower the principal's cost of implementing the efficient level of effort.

We can also show using the result established in Kim (1995) which is used in the proof of Proposition 1iii that implementing the high level of effort is less costly as the precision of the hard signal ρ_y increases. ■

Proof of Proposition 3. We know from the analysis of section 3.2 that it is optimal for the principal to design influence-free contracts as long as condition (1) is satisfied: $\alpha \rho_y (R(1) - R(0)) + \hat{\mathbf{w}}^I \mathbf{P}^I \geq \hat{\mathbf{w}}^F \mathbf{P}^F$. Also, we know from Propositions 1iii and 2iii that $\hat{\mathbf{w}}^I \mathbf{P}^I$ is increasing in α while $\hat{\mathbf{w}}^F \mathbf{P}^F$ is decreasing in α . As a result, $\frac{\partial R^{F>I}}{\partial \alpha} > 0$ where $R^{F>I} := \frac{\hat{\mathbf{w}}^F \mathbf{P}^F - \hat{\mathbf{w}}^I \mathbf{P}^I}{\alpha \rho_y} + R(0)$. We conclude that there exists a threshold

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for the principal's revenues when output is high ($R^{F>I}$) above which influence-free contracts are preferred to influence contracts. This threshold decreases in α . It follows that there exists a level of productivity above which high-productivity agents for which $R(1) \geq R^{F>I}$ will face an influence-free contract whereas low-productivity agents ($R(1) < R^{F>I}$) get an influence contract. ■

Proof of Proposition 4. Main text. ■

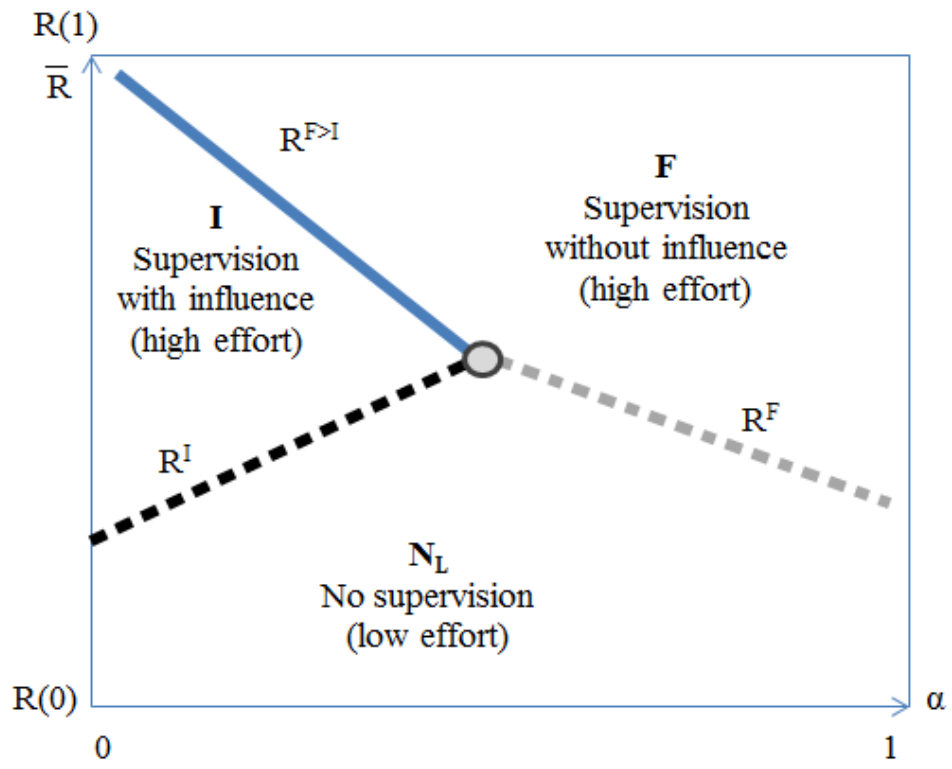


Figure 1. Principal's equilibrium strategy