# Information Transmission Through Influence Activities

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**Abstract**

We study information transmission aspect of influence activities in an organization where privately informed division managers manipulate information about their divisional "state" in order to sway the headquarters' decision in their favor. We formalize a notion of informativeness of influence activities, which we show is equivalent to sharpening the headquarters inference on the underlying state in the sense of second-order stochastic dominance, thus enhancing its surplus. We then provide sufficient conditions for the influence activities to be necessarily informative (detrimental, resp.) in equilibrium; and conditions on what kind of changes may induce more informative influence activities. Applying these results to various cases in which managers are motivated differently, we find that more conducive to informative influence activities are organizations that are less averse to risk taking, that rely more on higher-powered incentives such as bonus, and promote suitably-designed competition such as internal promotion.

Keywords: Influence activities, information transmission
JEL Classification Number: C72, D23, D82, L22

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# 1 Introduction

Influence activities in an organization are intended to affect decision making within the organization to the benefit of the party that engages in influence activities. Milgrom and Roberts (1988) highlight informational asymmetries as central to influence activities: the informed party optimally chooses influence activities in an attempt to influence the uninformed decision maker. The costs of influence activities include the resources that are devoted to affecting the distribution of benefits rather than to creating value, the value that is lost when influence results in suboptimal decisions, and the degradation in organizational performance that comes from altering policies, decision processes, or organizational structure to limit influence activities or their effects (Meyer, Milgrom and Roberts, 1992). On the other hand, influence activities can bring benefits in the form of information transmission that can improve decision making. Limiting influence activities could reduce influence costs but also stifle information transmission at the cost that valuable information is not made available to support decision making (Milgrom and Roberts, 1988, p S157).

Existing studies on influence activities either do not focus on the information transmission aspect or use the standard signal jamming approach where there is no sense in which valuable information is transmitted.[1] Thus there is a gap between the notion of influence activities originally put forward by Milgrom and Roberts (1988) and the literature that was developed subsequently. The purpose of our paper is to fill this gap by providing some insights as to when the influence activities can help information transmission and when they impede it.

We are interested in the effects of costly manipulation of noisy information on the underlying state by a party privately informed of it, with a view to influencing an uninformed party's decision that affects both parties' payoffs. To fix ideas, consider the capital allocation problem in a firm with an informed division manager and uninformed headquarters (HQ).[2] The return to capital depends on divisional state, which is either 'good' or 'bad' and is observed by the manager. The HQ observes only a noisy signal of the state before deciding how much capital to allocate to maximize the net return from the division. The manager's utility increases in the amount of capital allocated to his division, either directly or indirectly as described later. Thus the manager has incentives to distort the signal observed by the HQ. Such efforts, referred to as influence activities, result in a parallel shift of the distribution of the

[1] This literature is reviewed in Section 2.

[2] Our model is general enough for other interpretations. For example, one can think of the informed party as a firm's insider who communicates the firm's financial information to uninformed investors, who trade on the firm's shares based on the disclosed information.

signal,[3] which the HQ takes into account in inferring the underlying state from the observed signal. We say that influence activities are informative if they improve the HQ's inference relative to the benchmark case of no influence activity, and detrimental if they hamper it. We study how equilibrium influence activities hinge on the underlying environment, in particular, on the ways in which the manager is motivated, on the properties of the firm's overall performance indicator, and on divisional competition.

We start with a general model without imposing detailed structures on the manager's and the HQ's payoff functions except for the usual regularity conditions. After formalizing a definition of "more informative" influence activities in terms of the HQ's inference being closer to the true state, we obtain three main findings from the general model. First, more informative influence activities generate a posterior distribution that is second-order stochastically dominated by that generated by less informative ones, thus benefit the HQ via aligning its decision with the underlying state more precisely. This notion also conforms to the natural insight that the more divergent are the manager's influence activities across states, the more informative they are. Second, we provide sufficient conditions under which equilibrium influence activities are always informative, and those under which they are always detrimental. Third, we provide conditions that allow us to identify environments that admit an equilibrium with influence activities more informative than any given reference level.

We then study the implications of these main findings on different environments by imposing detailed structures, in order to understand better the relationship between the ways in which the manager is incentivized and the informativeness of influence activities. First, we consider the case where the manager only derives implicit private benefits proportional to the amount of capital allocated. In this case, the sufficient conditions for the influence activities to be informative simplify to a condition that hinges solely on how the HQ's marginal capital allocation changes as the posterior improves. Specifically, equilibrium influence activities are informative when it is larger when the state is more likely to be good, and detrimental otherwise. In the baseline case that the return from capital is higher by a fixed factor when the state is good than bad, this further implies that an informative equilibrium is more likely when the firm is less averse to risk taking as reflected in its performance indicator, and a detrimental equilibrium more likely when the firm is more conservative in its capital allocation.

Next, we consider the case where the manager is incentivized by explicit compensation that increases in line with the realized return, such as performance-based pay.

[3]For example, the manager may exaggerate the profit forecast or engage in cost padding, both of which can be viewed as adding a constant term to the actual divisional profitability or cost.

Such incentives are "higher-powered" in that the manager's benefit from more capital is amplified by marginal productivity of capital which we verify is uniformly higher when the underlying state is good than bad. Thus influence activities are assured to be informative in a wider range of environments. However, explicit incentives result in a departure from productive efficiency in capital allocation, because the HQ is no longer the sole residual claimant. Such a complicating factor exerts nontrivial feedback effects on the manager's choice of influence activity and for this reason, explicit incentives may not always be conducive to more informative influence activities.

Finally, we extend our analysis to multiple divisions in order to study whether the informativeness of influence activities may be enhanced by competition among division managers that naturally arises in organizations, such as internal promotion. By applying our general results described above, we demonstrate in a simple setting with two divisions that more informative influence activities can indeed be induced by a suitably devised divisional competition, even without inviting the aforementioned complicating factor of explicit incentives.

The remainder of this paper is organized as follows. After a review of related literature in Section 2, Section 3 describes the model. In Section 4, we formalize the notion of informativeness of influence activities and derive general results. In Section 5, we apply these results to the cases where the manager is motivated by implicit private benefits, explicit output-based incentives, and divisional competition. Section 6 contains concluding remarks and the appendix contains deferred proofs.

## 2 Related Literature

There are several ways the existing literature models influence activities in the firm. First, Milgrom (1988) studies influence activities in the firm's employment decisions although information transmission is not the main focus. In his model, an employee can spend time either on productive activity or on influence activity where the latter affects the probability that management's discretion will lead to a transfer of rent to the employee. Second, several studies model influence activities in the form of rent seeking (Bagwell and Zechner, 1993; Edlin and Stiglitz, 1995; Scharfstein and Stein, 2000; Inderst, Müller and Wärneryd, 2007).[4] Influence activities in these models are interpreted as an entrenchment strategy, or an attempt to raise bargaining power, or an effort to secure a share of the rent. Once again, information transmission is not

[4]Although rent seeking has the same objective as influence activities of affecting decision making within the organization, a crucial difference is that influence activities can transmit valuable information. Rent seeking, on the other hand, serves no function other than to transfer rents (e.g., Krueger, 1974).

the main focus in these studies. One could argue that these approaches are not true to the original spirit of Milgrom and Roberts (1988) in that they ignore the potential benefit from influence activities in the form of information transmission.

Influence over information received by headquarters is central in Milgrom and Roberts (1988), Meyer, Milgrom and Roberts (1992), and Wulf (2002). Information in the first two studies is for the firm's employment decisions while, in the third study, it is used for capital allocation within the firm. These authors use the modelling approach *à la* Fudenberg and Tirole (1986) and Holmström (1999), which we call the standard signal jamming model. The main difference between our model and the standard signal jamming model is that, in the latter, the player who takes an action to distort the signal does so before receiving private information.[5] As such, it results only in neutral influence activities in our terminology since it does not transmit valuable information: the receiver of information can perfectly back out any influence in equilibrium. As noted above, influence activities can be useful given the information asymmetry that pervades the organization. In our model, the manager engages in influence activities after observing the divisional state. Thus, unlike in the standard signal jamming model, some influence can transmit valuable information that can improve headquarters's inference.

Influence over information transmission is also central in the accounting literature on disclosure in general, and earnings management in particular.[6] In this literature, the firm's manager issues a report to the market either before or after receiving a private signal about firm value. The market updates its belief on firm value, which is impounded on the firm's stock price, which in turn affects the manager's payoff. Stein (1989) uses the standard signal jamming approach in that the earnings report is issued before the manager receives the signal. Therefore earnings management does not change the market's posterior. Others typically use the model of insider trading as in Kyle (1985). For example, Fischer and Verrecchia (2000), and Fischer and Stocken (2004) study earnings management after the manager receives the private signal. But they assume all relevant random variables are independent and normally distributed, and focus on linear reporting strategies. As a result, the equilibrium stock price is linear in report, which makes the equilibrium report independent of the private signal. Therefore, earnings management in these models does not have additional bite. In addition, the manager in these models issues a report after random noise is realized, hence there is little sense in which the manager's report conveys private information.

Finally, our model is different from standard signaling models since headquarters

[5] The same is true in the literature on Bayesian persuasion, e.g., Kamenica and Gentzkow (2011), in which the sender and the receiver start with symmetric information. In addition, the sender is restricted to communicate the observed signal truthfully by assumption.

[6] See Verrecchia (2001) for a comprehensive survey.

observes only a noisy signal of the underlying state. It also departs from the cheap-talk literature since there are exogenous costs to influence activities.[7] Thus our model is in the spirit of noisy signaling games such as Matthews and Mirman (1983), Carlsson and Dasgupta (1997), and de Haan, Offerman and Sloof (2011). The main focus in the first two studies is how the additional noise can reduce the set of equilibria, often to a unique separating equilibrium, while the third study looks at conditions under which both pooling and separating equilibria can exist. In contrast to these studies where the receiver's action is binary, we consider a richer set-up with continuous strategy space for the receiver. This allows us to characterize conditions for all possible types of equilibria, which we relate to different features of the underlying technology. In particular, we show that, in separating equilibria, both informative signaling and detrimental signaling are possible depending on the underlying technology.[8]

# 3 The Model

The model comprises two parties: headquarters (HQ) and a representative division manager of a firm.[9] Our focus is on how the HQ allocates capital to the division based on information that can be influenced by the division manager. The output from the division, denoted by $y(k, \theta)$, is determined by the amount of capital $k$ allocated to the division and the state of the division $\theta$. We treat $\theta$ as the realized value of a random variable $\tilde{\theta}$ with a binary support $\{H, L\} \subset \mathbb{R}$ where $H > L$. The commonly held prior probability that $\theta = H$ is $\lambda \in (0, 1)$. The HQ cannot observe $\theta$ but instead observes a signal $s$ correlated with $\theta$ as described below.

The manager observes $\theta$, and can boost the signal observed by the HQ by an amount $i \in \mathbb{R}_+$ through influence activity, at a cost of $c(i)$ that is increasing and strictly convex with $c(0) = c'(0) = 0$ and $\lim_{i\to\infty} c'(i) = \infty$. The HQ only observes a signal $s$ generated from a random variable $\tilde{s} = \theta + i + \varepsilon$ where $\varepsilon$ is a white noise distributed according to an atomless cumulative distribution function $F$ with an associated density function $f$ on $\mathbb{R}$. With slight abuse of notation, we use $f(\cdot|\theta + i)$ to denote the density function of $\tilde{s} = \theta + i + \varepsilon$. After observing $s$, the HQ chooses capital allocation $k$ which, in conjunction with $\theta$, determines the output $y(k, \theta)$. Note that the final signal $s$ received by the HQ is further modified by additional noise that is beyond the manager's control. The additional noise may represent simple observation

[7] Thus we also depart from Austen-Smith (1993) who models political lobbying as a cheap-talk game. In his model, there is cost in gathering information but communication itself is free.

[8] In de Haan, Offerman and Sloof (2011), separating equilibria are always informative in that 'good' type chooses more signaling than 'bad' type. In our detrimental equilibrium, the reverse is the case.

[9] We consider the case with more than one division in Section 5.3.

errors, frictions in the communication channel or influence activities by other division managers as in Wulf (2002).

We assume that the manager chooses $i$ after observing $\theta$. If the manager chooses $i$ before observing $\theta$, then we have the standard signal jamming model. In this case, as the HQ can correctly infer the level of influence in equilibrium, influence activities do not lead to distortion in capital allocation. The key aspect of capital allocation within the firm is the informational asymmetry between the HQ and the division manager: the division manager is better informed about the divisional state and tries to influence the HQ's capital allocation decision. In addition, there is ample empirical evidence on the distortion of capital allocation through internal capital markets.[10]

We also assume that the signal observed by the HQ is soft information, hence the HQ cannot commit to a capital allocation rule *ex-ante*. This is often assumed in the literature on internal capital markets (e.g., Scharfstein and Stein, 2000; Inderst and Laux, 2005). Moreover, influence activities are meaningful when the HQ has discretionary authority over decisions (Milgrom, 1988).

The manager is motivated by implicit or explicit incentives, the precise details of which depend on the specific compensation scheme adopted as illustrated later. For a more general analysis, here we represent the manager's utility as a function $u(k, \theta)$ of the amount of capital allocated to his division, $k \geq 0$, and the underlying state $\theta \in \{H, L\}$. If the manager's primary incentives are based on the private benefits from $k$, then $u$ depends directly on $k$. If the incentives are provided through explicit compensation based on output $y(k, \theta)$, then $u$ depends on $k$ indirectly through $y$. In any case, the manager chooses the level of influence activity $i$ to maximize the expected value of

$$u(k, \theta) - c(i) \tag{1}$$

contingently on the realized state $\theta$.

Let $i_H$ ($i_L$, resp.) denote the manager's choice of $i$ under the state $H$ ($L$, resp.). Then the HQ's posterior belief that $\theta = H$ upon observing a signal $s$, obtained by Bayes rule, is[11]

$$\mu(s|i_H, i_L) := \frac{\lambda f(s|H + i_H)}{\lambda f(s|H + i_H) + (1 - \lambda) f(s|L + i_L)} \tag{2}$$

whenever well-defined. The HQ allocates capital $k$ to maximize the output net of capital cost and any compensation payment to the manager. Thus, given a posterior

[10] See, for example, Stein (2003) and the references therein.

[11] Notice that, if the manager chooses $i$ before observing $\theta$ so that $i_H = i_L$, then the posterior belief in (2) would be the one as in the standard signal jamming model. Thus a key difference between our model and the signal jamming model is the possibility of $i_H \neq i_L$ in equilibrium.

belief $\mu \in [0,1]$ that $\theta = H$, the HQ solves

$$\max_{k \geq 0} \ \mu V(k,H) + (1-\mu)V(k,L) - k \tag{3}$$

where $V(k,\theta)$ is the HQ's objective function conditional on the divisional state being $\theta$, gross of capital cost which is normalized as 1 per unit. If the HQ maximizes the total output from the division then we have $V(k,\theta) = y(k,\theta)$, but $V$ and $y$ may differ generally. The solution to (3), which will satisfy the FOC due to assumptions to be imposed shortly, is denoted by

$$\kappa(\mu) > 0 \quad \text{that satisfies} \quad \mu V'(\kappa(\mu), H) + (1-\mu)V'(\kappa(\mu), L) = 1 \tag{4}$$

where $V'(\cdot,\theta)$ is the derivative of $V(\cdot,\theta)$ with respect to $k$.

Throughout the rest of the paper, we keep the following assumptions.

**Assumptions**

1. $f(\cdot)$ is continuous, single-peaked and symmetric around 0, and $f'(s) < 0$ at almost everywhere $s > 0$ such that $f(s) > 0$.

2. $f(\cdot|\theta + i)$ satisfies the monotone likelihood ratio property (MLRP): wherever well-defined, $f(s|\theta+i)/f(s|\theta'+i')$ is an increasing function of $s$ if $\theta+i > \theta'+i'$.

3. $V(k,H) > V(k,L)$; $V'(k,H) > V'(k,L)$; $V'(0,\theta) > 1$; $V'(\infty,\theta) < 1$; and $V''(k,\theta) < 0$.

Assumption 1 is satisfied by many known distributions and simplifies analysis. Assumption 2 is also standard and implies that the posterior belief $\mu(s|i_H, i_L)$ in (2) is increasing in $s$ if and only if $H + i_H > L + i_L$. Assumption 3 means that $V$ is increasing and strictly concave in $k$ and the marginal contribution of $k$ is higher when $\theta = H$. This is satisfied by various examples in the next section and implies $\kappa'(\mu) > 0$, i.e., optimal capital allocation increases in the HQ's posterior belief that $\theta = H$.

Given that the underlying signal technology $f$ satisfies Assumptions 1 and 2, we are interested in understanding how other aspects of the model, described by a tuple of functions $(V(k,H), V(k,L), u(k,H), u(k,L), c(i))$ which we call an *environment*, shape the equilibrium influence activities.

A signal technology $f$ and an environment define a game in which the division manager chooses influence activity level $i_\theta$ contingent on the divisional state $\theta \in \{H, L\}$ and the HQ chooses a capital allocation rule as a function of the signal $s$.

**Definition 1**: The manager's influence activities $(i_H^*, i_L^*)$, the HQ's capital allocation rule $k^*(s)$ and posterior belief $\mu^*(s)$ constitute an equilibrium if

$$(i) \quad i_\theta^* \in \arg\max_{i \geq 0} \int u(k^*(s),\theta) f(s|\theta + i)ds - c(i) \quad \text{for} \quad \theta \in \{H, L\}, \tag{5}$$

(*ii*) $k^*(s) = \kappa(\mu^*(s))$,
(*iii*) $\mu^*(s)$ is defined by Bayes rule whenever possible and is monotone in $s \in \mathbb{R}$.

Note that Bayes rule defines $\mu^*(s)$ on the whole domain $\mathbb{R}$ except for the case that $f$ has a bounded support. In the latter case, Bayes rule defines $\mu^*(s)$ on a subset of $\mathbb{R}$ which is monotonic due to MLRP, hence we require that $\mu^*(\cdot)$ be extended to the whole domain maintaining monotonicity, which is innocuous for our purpose.

# 4 Characterization of Equilibrium

## 4.1 Informativeness of influence activities

Since our main focus is on when influence activities can improve the HQ's inference on the underlying state $\theta \in \{H, L\}$, we start by formalizing the notion of influence activities being more informative. The well-known notion of Blackwell informativeness (Blackwell, 1951) is too stringent for our purpose as it requires a more informative information structure to be better for the decision maker for every possible prior distribution, whereas the prior is commonly known in our model at the outset.

Fundamentally, the HQ is better informed if it ends up assigning a higher posterior belief to the true state on average. We provide a definition formalizing this notion of comparing distributions of posterior probabilities, and show that it is equivalent to the second-order stochastic dominance relation. Moreover, we show that this definition orders any two profiles of influence activities, and is consistent with the natural insight that the farther away the manager's actions are across states, the more informative are the signals and consequently, the higher is the HQ's optimized payoff.

The posterior beliefs capture the likelihood of each state being the true state, revised from the prior. Hence, the HQ's inference is improved if the likelihood of each state gets revised up more when that state is indeed the true state. To formalize this idea, let $\Pi_\theta(p|i_H, i_L)$ denote the probability that at least probability $p$ is assigned to $\theta$ by the posterior generated under the influence activities $(i_H, i_L)$, conditional on $\theta$ being the true state: that is,

$$\begin{aligned}
\Pi_H(p|i_H, i_L) &:= Prob(\mu(s|i_H, i_L) \geq p \,|\, \theta = H) \\
\Pi_L(p|i_H, i_L) &:= Prob(\mu(s|i_H, i_L) < 1 - p \,|\, \theta = L).
\end{aligned}$$

**Definition 2**: Influence activities $(i_H, i_L)$ are *more informative* than $(i'_H, i'_L)$ if, for each $\theta \in \{H, L\}$, $\Pi_\theta(p|i_H, i_L) > \Pi_\theta(p|i'_H, i'_L)$ for all $p$ higher than the prior probability of $\theta$.[12] Influence activities $(i_H, i_L)$ are *informative* if they are more informative than

[12] To be fully precise, the inequality is required for $p = 1$ only if the support of $f$ is bounded.

$(0,0)$, i.e., no influence activity; *detrimental* if the converse holds; and *neutral* if neither holds.

We now establish that $H + i_H^* > L + i_L^*$ holds in equilibrium. To verify this, suppose on the contrary that $H + i_H^* \leq L + i_L^*$ in equilibrium. Then, MLRP would imply that the posterior is higher for lower signal ($\mu'(s) \leq 0$) and consequently, more capital gets allocated for lower signal, $\frac{dk^*(s)}{ds} \leq 0$. Thus, a higher $i$ increases cost for the manager without increasing capital allocation. This would imply $i_H^* = i_L^* = 0$, contradicting $H + i_H^* \leq L + i_L^*$. Therefore,

**Lemma 1**: In equilibrium, $H + i_H^* > L + i_L^*$ and $\frac{dk^*(s)}{ds} > 0$.

The next lemma shows that influence activities are informative if the manager does more of them when $\theta = H$ than when $\theta = L$. Note that what matters for the HQ's inference is the difference in the level of influence activities between the two states. For instance, if the manager chooses the same level of influence activities in both states, then the HQ discounts the value of observed signal by the amount of influence and consequently, influence has no effect on the HQ's inference (as in the signal jamming model). Thus influence activities can have an effect on the HQ's inference when the levels differ between the two states. Then the MLRP implies that influence activities are informative when they are done more under $\theta = H$ and detrimental when done more under $\theta = L$.

**Lemma 2**: Provided that $H+i_H > L+i_L$, $\Pi_\theta(p|i_H, i_L)$ is determined by and increases in $i_H - i_L$ for $p$ higher than the prior probability of $\theta$, thus influence activities $(i_H, i_L)$ are more informative as $i_H - i_L$ is larger. In particular, they are (a) informative if and only if $i_H > i_L$, (b) neutral if and only if $i_H = i_L$, and (c) detrimental if and only if $i_H < i_L$.

**Proof**: See the appendix.

As such, more informative influence activities generate a posterior distribution that is more concentrated toward the two extreme posteriors, in the sense of mean-preserving spread or equivalently, second-order stochastic dominance. This benefits the HQ since its optimized payoff is convex in the posterior due to Assumption 3.

**Proposition 1**: More informative influence activities generate a posterior distribution that is second-order stochastically dominated by that generated under less informative influence activities. The HQ's optimized payoff strictly increases as the influence activities become more informative.

**Proof**: See the appendix.

## 4.2 Results on equilibrium influence activities

We now turn to the equilibrium characterization and discuss when influence activities are informative, neutral, or detrimental. From the manager's optimization problem (5), the first-order conditions for $(i_H^*, i_L^*)$ are

$$\int_{-\infty}^{\infty} u'(\kappa(\mu^*(s)), \theta)\kappa'(\mu^*(s))\mu^{*\prime}(s) f(s|\theta + i_\theta^*) ds = c'(i_\theta^*), \quad \theta = H, L. \tag{6}$$

In choosing influence activity level, therefore, the manager balances the cost against the expected marginal utility from enhancing the HQ's posterior, $u'(\kappa(\mu), \theta)\kappa'(\mu)$. Under the uniform prior $\lambda = 1/2$, for instance, the posterior distributions under the two states are mirror images of each other around $\mu = 1/2$, but skewed to the right (left) under $\theta = H$ ($\theta = L$). Thus, if $u'(\kappa(\mu), H)\kappa'(\mu) > u'(\kappa(1-\mu), L)\kappa'(1-\mu)$ for all $\mu > 1/2$, the manager's marginal utility from the HQ's improved posterior is higher when $\theta = H$ than when $\theta = L$ and consequently, the manager engages in more influence activities when $\theta = H$.

To extend this condition to general $\lambda$, we observe that the posterior under $(i_H, i_L)$ is $\lambda$ at the signal $\bar{s} = (H + i_H + L + i_L)/2$; and if the posterior is $\mu > \lambda$ at some signal $s > \bar{s}$, the posterior at the signal $2\bar{s} - s$, i.e, on the other side of $\bar{s}$ by the same amount, is $x(\mu) := \frac{\lambda^2(1-\mu)}{\lambda^2(1-\mu)+(1-\lambda)^2\mu}$. We compare $u'(\kappa(\mu), H)\kappa'(\mu)$ with $u'(\kappa(x(\mu)), L)\kappa'(x(\mu))$ because $f(s|H + i_H) = f(2\bar{s} - s|L + i_L)$.

**Definition 3**: Marginal utility of posterior (MUP) is *upward-skewed* if

$$u'(\kappa(\mu), H)\kappa'(\mu) \;\geq\; u'(\kappa(x(\mu)), L)\kappa'(x(\mu)) \qquad \forall \mu \in (\lambda, 1) \tag{7}$$

with strict inequality for a positive mass of $\mu$; *downward-skewed* if the weak inequality is reversed in (7); and *symmetric* if the inequality is replaced with an equality in (7).

We state the first general result below, which identifies environments in which influence activities are necessarily informative, detrimental, and neutral, respectively.

**Proposition 2**:
(a) Equilibrium influence activities are informative if $\lambda \leq 1/2$ and $u'(k, H) \geq u'(k, L)$ for all $k \geq 0$ and MUP is upward-skewed.
(b) Equilibrium influence activities are detrimental if $\lambda \geq 1/2$ and $u'(k, H) \leq u'(k, L)$ for all $k \geq 0$ and MUP is downward-skewed.
(c) Equilibrium influence activities are neutral if $\lambda = 1/2$ and $u'(k, H) = u'(k, L)$ for all $k \geq 0$ and MUP is symmetric.

**Proof**: See the appendix.

In the next section, we provide several examples of environments to which the above result can be applied. More precisely, we consider various ways the manager can be incentivized. This adds more structure to the function $u(k,\theta)$, allowing us to readily check the condition (7). For example, if the manager is implicitly motivated by the size of the allocated capital so that $u'(\kappa(\mu),\theta)$ is a constant, then the informativeness of influence activities is determined solely by the prior and the HQ's optimal capital allocation rule $\kappa(\cdot)$.

Proposition 2 delivers a strong characterization in that it applies to all equilibria in a given environment, but the conditions are also strong as the same inequality must hold for every $\mu > \lambda$. Also, for it to be practically useful an equilibrium must exist, which is not warranted. We now turn our attention to environments in which equilibrium is guaranteed to exist by Kakutani's Fixed Point Theorem and provide a more lenient condition that warrants an equilibrium that is more informative than any given reference level.

In equilibrium the manager solves (5) contingent on $\theta \in \{H, L\}$, in particular, presuming that HQ believes that influence activities are $(i_H^*, i_L^*)$. Let $BR_\theta(i_H^*, i_L^*) \neq \emptyset$ denote the solution set, i.e, the set of optimal influence activity levels when the true state is $\theta$, given $(i_H^*, i_L^*)$. It is nonempty because the objective function is continuous in $i$, assumes a positive value at $i = 0$, and negative values for sufficiently large $i$ since $u(\cdot,\theta)$ is uniformly bounded above whereas $c(i)$ increases without bound. By the same token, $BR_\theta(i_H, i_L)$ is nonempty and uniformly bounded above, say by $M > 0$, for every $(i_H, i_L) \in \mathbb{R}_+^2$. Consequently, the best-response correspondence $BR : [0, M]^2 \to\to [0, M]^2$ is well-defined as

$$BR(i_H, i_L) = BR_H(i_H, i_L) \times BR_L(i_H, i_L),$$

and any fixed point of $BR$ constitutes an equilibrium and vice versa. If $BR$ is convex-valued and upper semi-continuous, a fixed point is warranted to exist (hence so is an equilibrium) by Kakutani's Fixed Point Theorem.

We now focus on environments in which $BR$ is convex-valued and upper semi-continuous. Consider, for instance, the cases in which the HQ believes influence activities are neutral, i.e, the same level in both states, say $i$. The manager's marginal utility from the influence activity evaluated at that level $i$, i.e., the left-hand side (LHS) of (6) when $i_H^* = i_L^* = i$, is the same for all values of $i$, which we denote by $MU_\theta$ for $\theta \in \{H, L\}$. For each $\theta \in \{H, L\}$, find the value of $i$ at which $c'(i) = MU_\theta$, denoted by $i_\theta^0$. Then, $i_\theta^0$ is the optimal level of influence activity under the state $\theta$,[13] conditional on the HQ believing $i_\theta^0$ to be the common influence activity level: that is,

[13] The FOC is sufficient for optimality when $BR$ is convex-valued and upper semi-continuous.

$i^0_\theta \in BR_\theta(i^0_\theta, i^0_\theta)$. Here, the superscript 0 is designatory of the HQ's belief satisfying $i_H - i_L = 0$.

Suppose $MU_H > MU_L$, so that $i^0_H > i^0_L$ due to convexity of $c(\cdot)$. This reflects that the marginal utility from enhancing the HQ's posterior is larger under $\theta = H$ when the HQ's believes that $i_H - i_L = 0$. If the HQ's belief changes in such a way that $d = i_H - i_L$ increases from 0, the HQ adjusts optimal capital allocation, which in turn changes the manager's marginal utility from enhancing HQ's posterior and thus, the optimal influence activity levels. Consider, in particular, the level for each state that is actually optimal when anticipated by the HQ subject to $i_H - i_L = d$, which we denote by $i^d_H \in BR_H(i^d_H, i^d_H - d)$ and $i^d_L \in BR_L(i^d_L + d, i^d_L)$. These levels may change in varying directions and magnitudes across the two states depending on the HQ's objective function. However, so long as they change in a continuous manner from $(i^0_H, i^0_L)$, there exists $d^* \in (0, M)$ such that $i^{d^*}_H - i^{d^*}_L = d^* > 0$: this is so because $i^d_H$, exceeding $i^d_L$ by $d$ yet bounded above by $M$, must hit $d$ for some $d < M$, while $i^d_L > 0$ holds always. Note that $(i^{d^*}_H, i^{d^*}_L) \in BR(i^{d^*}_H, i^{d^*}_L)$, thus constitutes an equilibrium with $i^{d^*}_H - i^{d^*}_L > 0$.

We generalize this observation to a sufficient condition for an equilibrium to exist with influence activities $(i^*_H, i^*_L)$ such that $i^*_H - i^*_L$ exceeds any given level $\Delta$. As revealed in the above illustration, $BR$ need not be convex-valued and upper semi-continuous on the entire domain but only for $(i_H, i_L)$ such that $i_H - i_L \geq \Delta$.

**Proposition 3**: Suppose that $i_H \in BR_H(i_H, i_H - \Delta)$ and $i_L \in BR_L(i_L + \Delta, i_L)$ imply $i_H > i_L + \Delta$ for some $\Delta \in \mathbb{R}$ and $BR$ is convex-valued and upper semi-continuous on $\{(i_H, i_L) \in \mathbb{R}^2_+ | i_H - i_L \geq \Delta\}$. Then there exists an equilibrium with influence activities $(i^*_H, i^*_L)$ such that $i^*_H - i^*_L > \Delta$.

**Proof**: See the appendix.

The following corollaries are immediate from Proposition 3.

**Corollary 1**: If $BR$ is convex-valued and upper semi-continuous on $\{(i_H, i_L) \in \mathbb{R}^2_+ | i_H \geq i_L\}$ and there exist $i_H \in BR_H(i_H, i_H)$ and $i_L \in BR_L(i_L, i_L)$ such that $i_H > i_L$, then an informative equilibrium exists.

Corollary 1 is pertinent, for example, when $u(k, H) = u(k, L)$ and $\kappa(\mu)$ is convex in $\mu$, so that the LHS of (6) is higher for $\theta = H$ than $\theta = L$. Suppose the manager is motivated only through private benefits that are linear in the size of allocated capital. Then we have $u(k, H) = u(k, L)$ and the HQ's optimal capital allocation $\kappa$ depends on the curvature of $y$. In Section 5.1, we show that $\kappa$ is convex in $\mu$ if $y$ is not "too concave". Note, however, that Corollary 1 does not preclude the possibility that a detrimental equilibrium may also exist.

**Corollary 2**: Suppose $(i_H^*, i_L^*)$ constitutes an equilibrium in a given environment. Consider a new environment in which all $i > i_L^*$ is suboptimal under $\theta = L$ relative to a belief $(i_H', i_L^*)$ where $i_H' \geq i_H^*$ and all $i \leq i_H'$ is suboptimal under $\theta = H$ relative to $(i_H', i_L^*)$. If $BR$ is convex-valued and upper semi-continuous on $\{(i_H, i_L) \in \mathbb{R}_+^2 | i_H - i_L \geq i_H' - i_L^*\}$, then an equilibrium exists that is more informative than $(i_H^*, i_L^*)$.

**Proof.** From the assumption that $i \notin BR_L(i_L^* + \Delta, i_L^*)$ for all $i > i_L^*$ where $\Delta = i_H' - i_L^* \geq i_H^* - i_L^*$, it follows that $i_L \in BR_L(i_L + \Delta, i_L)$ holds only for some $i_L \leq i_L^*$. Analogously, the assumption that $i \notin BR_H(i_H', i_H' - \Delta)$ for all $i \leq i_H'$ implies $i_H'' \in BR_H(i_H'', i_H'' - \Delta)$ only for some $i_H'' > i_H'$. Then Corollary 2 follows from Proposition 3. ∎

Corollary 2 concerns what kind of changes in environment may induce more informative influence activities. For example, suppose that cost of influence activities changes in such a way that $c'(i)$ increases slightly around $i_L^*$ and/or decreases slightly around $i_H^*$. Then the conditions of Corollary 2 are satisfied (for $i_H' = i_H^*$) and a more informative equilibrium exists in the new environment. This is intuitively clear since, in the new environment, marginal cost of influence activities increases when $\theta = L$ and decreases when $\theta = H$. In addition, we apply Corollary 2 in Section 5.3 to show that a suitably designed competition between division managers can induce more informative influence activities.

A potential issue in applying Proposition 3 is ensuring that $BR$ is convex-valued and upper semi-continuous for the relevant domain. Although we do not have a broadly applicable characterization of when this condition is satisfied, there are simple classes of environments in which it is satisfied and thus, Proposition 3 is applicable. Below we illustrate such a class of environments.

**Example 1:** Consider the simplest signal technology $f$ subject to Assumptions 1 and 2: $f(s) = 1 + s$ for $s \in [-1, 0]$ and $f(s) = 1 - s$ for $s \in [0, 1]$. Assume $H = 1$ and $L = 0$ and $u(k, H) = u(k, L) = k$ as in Section 5.1 below. Then, relative to $(i_H, i_L) = (i, i)$, the posterior is $\mu(s) = s$ for $s \in [i, i+1]$ while $\mu(s) = 0$ for $s < i$ and $\mu(s) = 1$ for $s > i + 1$; and the marginal utility of influence activity at $i$ under $\theta = L$ and $\theta = H$ is, respectively,

$$MU_L = \int \kappa'(\mu(s))\mu'(s)f(s|i)ds = \int_i^{i+1} \kappa'(s-i)f(i+1-s)ds = \int_0^1 \kappa'(s)(1-s)ds,$$

$$MU_H = \int \kappa'(\mu(s))\mu'(s)f(s|i+1)ds = \int_i^{i+1} \kappa'(s-i)f(s-i)ds = \int_0^1 \kappa'(s)s\,ds.$$

As $i_\theta \in BR_\theta(i_\theta, i_\theta)$ implies $c'(i_\theta) = MU_\theta$, we have $i_L < i_H$ if and only if $MU_L < MU_H$, an inequality determined by the shape of $\kappa'(\cdot)$. If $MU_L < MU_H$ holds, an informative equilibrium exists by Corollary 1 provided that $BR$ is convex-valued and upper semi-continuous on $\{(i_H, i_L) \in \mathbb{R}^2_+ | i_H \geq i_L\}$. Indeed, this condition on $BR$ holds for a broad class of $\kappa$ and $c$ functions, in particular, when $\kappa'$ is not very volatile and $c$ is sufficiently convex, as we verify in the appendix.

# 5 Managerial Incentives and Influence Activities

In this section, we examine the implications of the results obtained in the previous section for three classes of environments that differ in the way in which the manager is incentivized. First, we study the case where the incentives are provided only through implicit private benefits, derived from the size of allocated capital.[14] Next, we consider the case where the manager is motivated by an explicit compensation payment that is linear in the realized output, stock-based compensation in listed firms being an example. We then consider the effect of competition between two divisions where the manager is motivated through internal promotion, which has a feature of tournament subject to some performance hurdle. For the analysis in this section, we assume a uniform prior $\lambda = 1/2$ for the sake of simpler notation and clearer presentation of the main insights.

## 5.1 Implicit incentives

Consider the case where the manager is motivated only through non-contractible, private benefits from the capital allocation. Specifically, assume that $u(k, \theta) = ak$ where $a > 0$. Then, the HQ solves (3) where $V(k, \theta) = y(k, \theta)$, i.e,

$$\max_{k \geq 0} \ \mu y(k, H) + (1 - \mu) y(k, L) - k. \tag{8}$$

We assume that

$$y'(0, \theta) > 1, \ y'(\infty, \theta) < 1, \ y'(k, H) > y'(k, L), \ y''(k, \theta) < 0, \quad \text{and} \quad y(k, H) \geq y(k, L),$$

[14]This portrays situations in which managerial compensation is largely based on fixed salary or performance signal is highly noisy. For example, managerial behavior in non-profit organizations or bureaucracies could fit this case: non-profit organizations are typically bound by a ‘nondistribution constraint’, which prohibits them from distributing profits to their managers (Ballou and Weisbrod, 2003). Studies in bureaucracies (e.g., Niskanen, 1971; Tullock, 1965) have long argued bureaucrats’ preference for larger budgets. Khalil et al. (2013) provide various reasons for low-powered incentives for bureaucrats. They also discuss the political science literature on why funding authorities may have little control over a bureaucratic agency other than being able to fix its budget.

so that Assumption 3 is satisfied, where we treat $y(k,\theta)$ as a function of $k$ given $\theta \in \{H, L\}$ and denote its derivatives by $y'(k,\theta)$, $y''(k,\theta), \cdots$, for notational ease. Then $\kappa$ satisfies

$$\mu y'(\kappa(\mu), H) + (1-\mu)y'(\kappa(\mu), L) = 1 \tag{9}$$

and thus, $\kappa'(\mu) > 0$. In this case, $u'(k,H) = u'(k,L) = a$, hence Proposition 2 leads to the following.

**Corollary 3**: Suppose that $u(k,\theta) = ak$ and $V(k,\theta) = y(k,\theta)$ for $\theta \in \{H, L\}$.
(a) Equilibrium influence activities are informative if $\kappa'(\mu) \geq \kappa'(1-\mu)\ \forall \mu \in (1/2, 1)$ with strict inequality for a positive mass of $\mu$.
(b) Equilibrium influence activities are detrimental if the inequality in (a) is reversed.
(c) Equilibrium influence activities are neutral if $\kappa'(\mu) = \kappa'(1-\mu)\ \forall \mu \in (1/2, 1)$.

In particular, influence activities are informative (detrimental, resp.) if $\kappa(\mu)$ is convex (concave, resp.) because $d^2\kappa/d\mu^2 \geq 0$ ($\leq 0$, resp.) implies the inequality in (a) ((b), resp.) of Corollary 3. Moreover, we can relate the curvature of $\kappa$ to the derivatives of $y$. Denote $\Delta y' := y'(k,H) - y'(k,L)$, $\Delta y'' := y''(k,H) - y''(k,L)$, $Ey'' := \mu y''(k,H) + (1-\mu)y''(k,L)$, and $Ey''' := \mu y'''(k,H) + (1-\mu)y'''(k,L)$. Then we have (as proved in the appendix):

$$\frac{d^2\kappa}{d\mu^2} \geq 0 \quad \Longleftrightarrow \quad \frac{2\Delta y''}{\Delta y'} \geq \frac{Ey'''}{Ey''}. \tag{10}$$

This condition is useful in understanding how the underlying environment, the output function $y$ and the manager's implicit incentives in particular, can be mapped to the informativeness of influence activities. Corollary 3 implies that equilibrium influence activities are informative if the inequality in (10) holds and detrimental if the opposite inequality holds. Nonetheless the condition involves third derivatives and one might question its intuitive appeal. To provide intuition, suppose $y(k,\theta)$ is multiplicatively separable in that $y(k,\theta) = \theta y(k)$. Then $Ey'' = [\mu H + (1-\mu)L]y''$ and $Ey''' = [\mu H + (1-\mu)L]y'''$. Thus the RHS of condition (10) boils down to $y'y''' \geq 2(y'')^2$. This condition roughly implies that, as $k$ increases, the marginal return to capital decreases at an increasingly slower rate, or $y$ becomes less concave.[15] In this case, the HQ would increase capital allocation in an increasing rate as its posterior belief improves. As a result, $\kappa$ is a convex function of $\mu$. This implies that, as the HQ's objective $y$ becomes less concave, equilibrium influence activities are more likely to be informative.

[15] We can also interpret this condition in a way similar to how risk aversion is measured. Analogous to the Arrow-Pratt measure of absolute risk aversion, define $A(k) := -y''(k)/y'(k)$. Then $A'(k) \geq 0$ if and only if $(y'')^2 \geq y'y'''$. Thus $y'y''' > 2(y'')^2$ implies $A'(k) < 0$, or $y$ becomes less concave.

The condition (10) may be better understood by considering three familiar classes of strictly concave functions. Suppose first $y(k) = \alpha k^n$ where $\alpha > 0$ and $n < 1$. Then we have $y'y''' > 2(y'')^2$, hence $\kappa$ is a convex function of $\mu$ and therefore, equilibrium influence activities are informative. Our next example is $y(k) = \beta \log(k + 1)$ where $\beta > 0$. In this case, $y'y''' = 2(y'')^2$. Therefore $\kappa$ is an increasing, affine function of $\mu$, hence neutral equilibrium influence activities. Finally if $y(k) = A - Be^{-\gamma k}$ where $\gamma, A, B > 0$, we have $y'y''' < 2(y'')^2$. Thus $\kappa$ is a concave function of $\mu$, hence detrimental equilibrium influence activities. Plotting these three functions, we can see that the rate of decrease in the second derivative is the largest for the negative exponential function and the smallest for the power function.

A further interpretation of Corollary 3 is possible when we interpret $y$ more generally as an organization's performance indicator that also reflects its internal culture. When $y$ is less concave, we may say the organization is less averse to risk taking: it responds more aggressively when the good prospect improves even further than when the bad prospect turns better. Such a culture encourages informative communication. On the other hand, a more conservative organization with more concave $y$ does not respond as aggressively to an improvement in the good prospect. In this case, detrimental communication to cover up bad news is more likely.[16]

## 5.2 Explicit incentives

We now consider the case where the manager is paid an explicit compensation based on output. Then the eventual effect on the manager's utility of boosted signals due to influence activities can be understood in two stages. First, they induce increased capital allocation by the HQ, which will then increase the divisional output. Since the increase in output due to increased capital is larger under $\theta = H$, the manager benefits more from influence activities when $\theta = H$ than when $\theta = L$.

The above discussion seems to suggest that equilibrium influence activities are more likely to be informative when the manager is motivated through explicit incentives than through implicit benefits. However, this insight is not necessarily true owing to a complicating factor that the HQ is no longer a residual claimant in this case, which can lead to a distortion in capital allocation.[17] Below we elaborate on this issue and clarify the extent to which the insight is valid nonetheless, for the simple

[16] Another way to interpret these conditions is the organization's asymmetric response to information. That is, an organization with an aggressive (conservative, resp.) capital allocation rule responds more (less, resp.) to the arrival of good information than to the arrival of bad information. Such asymmetric responses to information are well-documented in politics, financial markets, etc. See, for example, Soroka (2006) and the references therein.

[17] Finding an optimal compensation scheme is a challenging task for this reason and beyond the scope of this paper.

case where the compensation payment is linear in output.

Suppose the manager's compensation is $u(k,\theta) = b \cdot y(k,\theta)$ where $b \in (0,1)$.[18] Then, the HQ solves (8) with $y$ replaced by $(1-b)y$, and the FOC is (9) with the LHS multiplied by $(1-b)$. The policy function that satisfies this modified FOC, which we denote by $\hat{\kappa}(\mu)$ to distinguish from the previous $\kappa(\mu)$, prescribes a suboptimal level of capital allocation conditional on $\mu$ because the HQ does not internalize the part of output used to compensate the manager. As $y'(\hat{\kappa}(0), L) = y'(\hat{\kappa}(1), H) = 1/(1-b)$ from (9),

$$y'(\hat{\kappa}(\mu), H) > 1/(1-b) > y'(\hat{\kappa}(\mu), L) \quad \text{for all} \quad \mu \in (0,1). \tag{11}$$

Hence, only part (a) of Proposition 2 is readily applicable in this case (recall $\lambda = 1/2$):

**Corollary 4**: Suppose the manager is motivated by a linear compensation scheme $u(k,\theta) = b \cdot y(k,\theta)$. Then, equilibrium influence activities are informative if

$$y'(\hat{\kappa}(\mu), H)\hat{\kappa}'(\mu) \;>\; y'(\hat{\kappa}(1-\mu), L)\hat{\kappa}'(1-\mu) \quad \forall \mu \in (1/2, 1),$$

which is the case if $2\Delta y''/\Delta y' \geq Ey'''/Ey''$.

Note that the environments that guarantee informative influence activities are strictly larger under explicit incentives (Corollary 4) than under implicit incentives (Corollary 3). This is because explicit incentives are "higher-powered" in the sense that the manager's benefit from more capital is amplified by marginal productivity of capital which is uniformly higher when the underlying state is $H$ as shown in (11).

Nevertheless, this falls short of a general conclusion that influence activities are more informative under explicit incentives than under private benefits. For example, when Corollaries 3 and 4 are inapplicable because the inequalities therein hold for some but not all values of $\mu$, it is possible that the change from $\kappa$ to $\hat{\kappa}$ renders influence activities more attractive when $\theta = L$ under explicit incentives (e.g., because $\hat{\kappa}'$ is higher for low values of $\mu$). Moreover, explicit incentives result in a departure from productive efficiency in capital allocation, damaging total welfare. Such complicating effects are inevitable because explicit incentives transfer part of residual claim to the manager, hence distorts capital allocation by the HQ, which in turn affects the manager's influence activities. In the next section we show that introducing competition between division managers may elicit more informative influence activities without inviting such complicating factors.

[18] Alternatively, we may consider the case that the manager's utility is the sum $ak^*(s)+by(k^*(s),\theta)$, in which case the same results hold qualitatively. The subsequent analysis also remains valid when $by'(\hat{\kappa}(\mu(s|i^*)),\theta)$ is replaced by $a + by'(\hat{\kappa}(\mu(s|i^*)),\theta)$.

## 5.3 Competition

It is often argued that competition for scarce resources increases division managers' incentives to engage in influence activities. Indeed this has been one of the explanations for the so-called conglomerate discount (Scharfstein and Stein, 2000; Rajan, Servaes and Zingales, 2000) and used to provide a rationale for divestiture (Meyer, Milgrom and Roberts, 1992). However, how or whether competition affects influence activities has not been rigorously studied when influence activities transmit information. In this section, we apply Proposition 3 and illustrate in a simple setting that competition can be conducive to more informative influence activities.

Recall that the division manager in the baseline model is representative of multiple, independent ones governed by the same HQ. Consider now a case where there are two symmetric divisions as described in Section 3 with uncorrelated divisional states. Then the HQ's capital allocation and the manager's influence activities of each division are determined independently of the other division, thus the equilibrium characterizations in the previous sections apply to both divisions separately. Suppose a symmetric equilibrium prevails in which both managers engage in influence activities $(i_H^*, i_L^*)$.

We show that the HQ can induce more informative influence activities by introducing competition through a suitably-devised prize scheme. We present the prize scheme in the context of internal promotion, although it could also be interpreted as a monetary prize. To facilitate the discussion using the results from our baseline model, we consider the following internal promotion scheme which does not affect the HQ's capital allocation problem:

i) The HQ sets a threshold output level $y^* > 0$ and the internal promotion rule as described below.

ii) If only one division produces output in excess of $y^*$, the manager of that division is promoted and receives an extra utility of $Z$ (be it from a higher salary or status), leaving the other manager with no extra utility as he loses the chance of promotion.

iii) In all other cases, both managers have equal chance of being promoted, with a corresponding expected extra utility of $Z/2$ each.

iv) The aggregate utility of each manager is $u(k, \theta) + B$ where $\theta$, $k$ and $B$ are, respectively, his divisional state, the capital allocated to his division and the extra utility from promotion.

Under the above scheme, since the total extra utility to be provided is equal to $Z$ in any case and the divisional states are uncorrelated, the HQ's capital allocation problem is independent across the two divisions. Thus the HQ's optimal capital allocation rule for each division is $k^*(s) = \kappa(\mu(s|i_H^*, i_L^*))$ as explained in Section 4 where $(i_H^*, i_L^*)$ are that division manager's influence activities.

However, compared with the case without the promotion scheme, the manager's utility is increased especially at high levels of $k$ due to enhanced chance of getting the promotion. This in turn increases his marginal utility from enhancing the HQ's posterior belief through more influence activity, insofar as it increases the probability of the divisional output to exceed the threshold level $y^*$. Therefore, if $y^*$ is deliberately chosen so that it is achievable only under $\theta = H$, which is the case if $y(\kappa(1), L) < y^* < y(\kappa(1), H)$, then the marginal utility of influence activity is boosted by the promotion scheme under $\theta = H$, but unchanged under $\theta = L$. It is because influence activity under $\theta = L$ does not affect the chance of getting the promotion and thus, the expected extra utility from promotion is the same regardless of the level of influence activity. Consequently, when the promotion scheme is introduced to the initial equilibrium with influence activities $(i_H^*, i_L^*)$, the marginal utility exceeds marginal cost at $i_H^*$ when $\theta = H$. But $i_L^*$ remains to be optimal under $\theta = L$. Therefore, from Corollary 2 (where $i'_H = i_H^*$) we deduce that a more informative equilibrium can be induced by introducing a promotion scheme, provided that the environment admits *BR* that is convex-valued and upper semi-continuous.

While we have framed our prize scheme in the context of internal promotion, one may also interpret this as a bonus scheme subject to some performance hurdle. For example, the HQ sets a prize pool of size $Z$ and a performance hurdle $y^*$. Only when one divisional output exceeds the performance hurdle, that manager is awarded the entire bonus while, in all other cases, the bonus is shared equally between the two managers. Such a bonus scheme is non-monotonic in a division's own output, which helps keep the HQ's capital allocation decision unaffected. We note that bonus schemes that have a feature of tournament can allow non-monotonic payment.

# 6 Conclusion

This paper has focused on the information transmission aspect of influence activities. Although influence activities are costly since they are not directly productive activities, they nonetheless play a role in transmitting valuable local information to the central decision maker. They are informative if they improve the central decision maker's inference and detrimental if they hamper it. We have considered several different environments and clarified when influence activities can be informative or detrimental. We find that influence activities are more likely to be informative in organizations that are less averse to risk taking, that encourage competition via suitably-designed prize schemes such as internal promotion, and that rely more on higher-powered incentives such as bonus. On the other hand, such effects may be hampered due to distorted capital allocation when higher-powered incentives are used.

Our findings offer some implications for optimal organization design. Particularly relevant is the issue of centralization versus decentralization. Although centralized organizations may be better at coordinating decisions,[19] they are more susceptible to influence activities since the center retains much of discretionary authority and communication tends to be vertical. Our findings suggest that centralized organizations can improve their vertical communication channels by using higher-powered incentives, introducing competition among divisions, and relying on performance indicators that encourage risk taking. If it is not possible to incorporate these elements in organization design for whatever reasons, then more decentralization can reduce detrimental influence activities. Given the difficulty in relying on high-powered incentives in bureaucracies, one could argue that more bureaucratic organizations are likely to benefit more from decentralization. An additional implication is that firms in growth industries where performance indicators tend to be more volatile than those in mature industries are more likely to benefit from informative influence activities.

## Appendix

**Proof of Lemma 2**: It is clear from (2) that $\mu(s+r|i_H+r, i_L+r) = \mu(s|i_H, i_L)$ for any $r \in \mathbb{R}$. So, $\Pi_H(p|i_H, i_L)$ and $\Pi_L(p|i_H, i_L)$ are determined by $\Delta i = i_H - i_L$. We show below that $\Pi_\theta(p|i_H, i_L)$ increase in $\Delta i$ for $p > \lambda$ when $\theta = H$ and for $p > 1-\lambda$ when $\theta = L$.

As $H + i_H > L + i_L$, we have $\mu(\bar{s}|i_H, i_L) = \lambda$ where $\bar{s} = \frac{H+i_H+L+i_L}{2}$. For $\mu(s|i_H, i_L) > \lambda$, we need $s > \bar{s}$ so that $f(s|H+i_H) > f(s|L+i_L)$. For $p = 1$, $\Pi_H(1|i_H, i_L) = \int_{\bar{s}_L}^{\infty} f(s|H+i_H)ds$ where $\bar{s}_L = \min\{s > L+i_L | f(s|L+i_L) = 0\}$, whence $\Pi_H(1|i_H+r, i_L) > \Pi_H(1|i_H, i_L)$ for $r > 0$ if $\Pi_H(1|i_H, i_L) > 0$.

For an arbitrary $p \in (\lambda, 1)$, there is a unique $s_p > \bar{s}$ such that $\mu(s_p|i_H, i_L) = p$ and $\Pi_H(p|i_H, i_L) = \int_{s_p}^{\infty} f(s|H+i_H)ds$. Consider $(i_H + r, i_L)$ where $r > 0$. Then $\mu(s_p + r|i_H + r, i_L) > \mu(s_p|i_H, i_L) = p$ since $f(s_p + r|H + i_H + r) = f(s_p|H + i_H)$ while $f(s_p + r|L + i_L) < f(s_p|L + i_L)$. Thus $\mu(s'|i_H + r, i_L) = p$ for some $s' < s_p + r$ by monotonicity of $\mu(\cdot|i_H + r, i_L)$. Consequently, $\Pi_H(p|i_H + r, i_L) = \int_{s'}^{\infty} f(s|H + i_H + r)ds = \int_{s'-r}^{\infty} f(s|H + i_H)ds > \int_{s_p}^{\infty} f(s|H + i_H)ds = \Pi_H(p|i_H, i_L)$, verifying that $\Pi_H(p|i_H, i_L)$ increase in $\Delta i$ for $p > \lambda$.

[19] Alonso et al. (2008) and Rantakari (2008) challenge this by showing that cheap talk communication between division managers can achieve coordination, the benefits of which improve with decentralization.

Symmetric arguments verify that $\Pi_L(p|i_H, i_L)$ increase in $\Delta i$ for $p > 1-\lambda$. Then, claims in the Lemma are immediate. $\blacksquare$

**Proof of Proposition 1:** By Lemma 2, it suffices to show that the posterior distribution generated by influence activities $(i_H, i_L)$ second-order stochastically dominates that generated by $(i_H + r, i_L)$ if $r > 0$, provided that the support of $f(\cdot|H + i_H + r)$ and that of $f(\cdot|L + i_L)$ has a nonempty interior. We show this in Steps 1-3 below, then show that HQ is better-off under $(i_H + r, i_L)$ in Step 4.

Step 1. Given $(i_H, i_L)$, consider a pair of signals $s > \bar{s} = \frac{H+i_H+L+i_L}{2}$ and $2\bar{s} - s$. The signals $s$ and $2\bar{s}-s$ are generated with densities $\lambda f(s|H+i_H)+(1-\lambda)f(s|L+i_L)$ and $\lambda f(2\bar{s}-s|H+i_H)+(1-\lambda)f(2\bar{s}-s|L+i_L) = \lambda f(s|L+i_L)+(1-\lambda)f(s|H+i_H)$, respectively. Thus the mean of the posteriors generated by $s$ and $2\bar{s} - s$ is

$$\frac{[\lambda f(s|H+i_H)+(1-\lambda)f(s|L+i_L)]\mu(s)+[\lambda f(s|L+i_L)+(1-\lambda)f(s|H+i_H)]\mu(2\bar{s}-s)}{f(s|L+i_L)+f(s|H+i_H)} = \lambda.$$

That is, the posterior distribution generated by $(i_H, i_L)$ exhibits the property that

$$\text{the density-weighted average of } \mu \text{ and } x(\mu) := \frac{(1-\lambda)^2\mu}{\lambda^2(1-\mu)+(1-\lambda)^2\mu} \text{ is } \lambda \text{ for all } \mu > \lambda. \tag{A1}$$

Step 2. Let $(i_H, i_L)$ be such that $H + i_H > L + i_L$ and $J$ be the distribution of the posterior $\mu$ generated from $(i_H, i_L)$. Similarly, let $G$ be the distribution of the posterior $\mu$ generated from $(i_H + r, i_L)$ for some $r > 0$. By Lemma 2, we may set $i_L = 0$ and relabel $H + i_H$ as a new $H$ in the rest of the proof. Then, $J$ is the distribution of posteriors generated by $i_0 = (i_H, i_L) = (0, 0)$, denoted by $\mu_o(s)$, and $G$ is that generated by $i_r = (i_H, i_L) = (r, 0)$, denoted by $\mu_r(s)$. Clearly $J$ and $G$ have the same mean.

If $J$ assigns a positive probability to $\mu = 1$, then $G$ clearly assigns a higher probability. We now show that

$$1 - J(\mu) < 1 - G(\mu) \quad \text{for all} \quad \mu \in (\lambda, 1). \tag{A2}$$

Without loss of generality we assume $\lambda \geq 1/2$ because otherwise we may swap $H$ and $L$ except the prior probabilities and the same analysis applies due to symmetry. In addition, we assume $r > 0$ small enough so that $f(H + r/2|H + r) > f(\bar{s}_0|H)$ where $\bar{s}_0 = \frac{H+L}{2}$, since we can apply the result successively for larger $r$.

For any given $t > \bar{s}_0$, let $\mu = \mu_o(t) > \lambda$. Let $t'$ be such that $\mu_r(t') = \mu$. Clearly, $\bar{s}_r = \frac{H+r+L}{2} < t' < t + r$ because $\mu_r(\bar{s}_r) = \lambda$ and $\mu_r(t + r) > \mu$.

If $t \geq H + r/2$, then $\mu_r(t) > \mu_o(t)$ so that $t' < t$ by monotonicity of $\mu_r$. Therefore, $1 - G(\mu) = \int_{t'}^{\infty}[\lambda f(s|H + r) + (1 - \lambda)f(s|L)]ds > \int_{t}^{\infty}[\lambda f(s|H) + (1 - \lambda)f(s|L)]ds = 1 - J(\mu)$.

For $t \in (\bar{s}_0, H + r/2)$, note that $J(\mu) - J(\lambda) = \int_{\bar{s}_0}^{t} [\lambda f(s|H) + (1-\lambda) f(s|L)]ds$. Moreover, $t' < t + \frac{r}{2}$ because $\mu_r(t + \frac{r}{2}) = \mu(t + \frac{r}{2}|i'_H, 0) > \mu(t|i'_H, 0) = \mu$ when $i'_H = 2(t - H) > L - H$ and the inequality is due to the MLRP. Thus, $G(\mu) - G(\lambda) = \int_{\bar{s}_0 + r/2}^{t'} [\lambda f(s|H + r) + (1-\lambda) f(s|L)]ds < \int_{\bar{s}_0 - r/2}^{t-r/2} \lambda f(s|H)ds + \int_{\bar{s}_0 + r/2}^{t+r/2} (1-\lambda) f(s|L)ds < \int_{\bar{s}_0}^{t} [\lambda f(s|H) + (1-\lambda) f(s|L)]ds = J(\mu) - J(\lambda)$. Since $1 - G(\lambda) \geq 1 - J(\lambda)$ due to $\lambda \geq 1/2$, this proves (A2) as desired.

Step 3. Fix an arbitrary non-increasing convex function $W : [0,1] \to \mathbb{R}$. By (A1), the density-weighted average of $W(\mu)$ and $W(x(\mu))$ is higher for higher $\mu > \lambda$. By (A2), therefore, we deduce that $\int W(\mu)dG \geq \int W(\mu)dJ$. This proves that $J$ second-order stochastically dominates $G$ (see Mas-Colell, *et al.*, 1995, p.197).

Step 4. Denote the HQ's optimized payoff by $W(\mu) := \mu V(\kappa(\mu), H) + (1-\mu) V(\kappa(\mu), L) - \kappa(\mu)$. Differentiating $W(\mu)$ wrt $\mu$, we get $W'(\mu) = V(\kappa(\mu), H) - V(\kappa(\mu), L)$ owing to (4) and consequently, $W''(\mu) = [V'(\kappa(\mu), H) - V'(\kappa(\mu), L)]\kappa'(\mu) > 0$ where the inequality follows from Assumption 3. Note that $W$ being non-increasing is irrelevant in concluding that $\int W(\mu)dG \geq \int W(\mu)dJ$ in Step 3. Since the HQ's payoff $W(\mu)$ is strictly convex, $\int W(\mu)dG > \int W(\mu)dJ$ ensues as desired. ∎.

**Proof of Proposition 2**: (a) Recall that $\mu(2\bar{s} - s) = x(\mu(s))$ for all $s > \bar{s} = \frac{H + i_H + L + i_L}{2}$. In addition,

$$\begin{aligned}
\mu'(s|i_H, i_L) &= \frac{\lambda(1-\lambda)[f'(s|H + i_H) f(s|L + i_L) - f(s|H + i_H) f'(s|L + i_L)]}{[\lambda f(s|H + i_H) + (1-\lambda) f(s|L + i_L)]^2} \\
\mu'(2\bar{s} - s|i_H, i_L) &= \frac{\lambda(1-\lambda)[f'(2\bar{s} - s|H + i_H) f(2\bar{s} - s|L + i_L) - f(2\bar{s} - s|H + i_H) f'(2\bar{s} - s|L + i_L)]}{[\lambda f(2\bar{s} - s|H + i_H) + (1-\lambda) f(2\bar{s} - s|L + i_L)]^2} \\
&= \frac{\lambda(1-\lambda)[-f'(s|L + i_L) f(s|H + i_H) + f(s|L + i_L) f'(s|H + i_H)]}{[\lambda f(s|L + i_L) + (1-\lambda) f(s|H + i_H)]^2} \\
&\leq \mu'(s|i_H, i_L) \quad \text{for} \quad s > \bar{s} \quad \text{so long as} \quad f(s|L + i_L) > 0,
\end{aligned}$$

where the weak inequality follows from $\lambda \leq 1/2$.

Comparing the LHS of the FOC in (6) for $\theta = H$ and $L$, we have

$$\begin{aligned}
& \int_{\mathbb{R}} u'(\kappa(\mu^*(s)), H)\kappa'(\mu^*(s))\mu^{*\prime}(s) f_H ds - \int_{\mathbb{R}} u'(\kappa(\mu^*(s)), L)\kappa'(\mu^*(s))\mu^{*\prime}(s) f_L ds \\
= & \int_{\mathbb{R}} \Big[ u'(\kappa(\mu^*(s)), H)\kappa'(\mu^*(s))\mu^{*\prime}(s) - u'(\kappa(\mu^*(2\bar{s}-s)), L)\kappa'(\mu^*(2\bar{s}-s))\mu^{*\prime}(2\bar{s}-s) \Big] f_H ds \\
= & \int_{\bar{s}}^{\infty} \Big[ u'(\kappa(\mu^*(s)), H)\kappa'(\mu^*(s))\mu^{*\prime}(s) - u'(\kappa(\mu^*(2\bar{s}-s)), L)\kappa'(\mu^*(2\bar{s}-s))\mu^{*\prime}(2\bar{s}-s) \Big] f_H ds \\
& + \int_{-\infty}^{\bar{s}} \Big[ u'(\kappa(\mu^*(s)), H)\kappa'(\mu^*(s))\mu^{*\prime}(s) - u'(\kappa(\mu^*(2\bar{s}-s)), L)\kappa'(\mu^*(2\bar{s}-s))\mu^{*\prime}(2\bar{s}-s) \Big] f_H ds \\
= & \int_{\bar{s}}^{\infty} \Big[ u'(\kappa(\mu^*(s)), H)\kappa'(\mu^*(s))\mu^{*\prime}(s) - u'(\kappa(x(\mu^*(s))), L)\kappa'(x(\mu^*(s)))\mu^{*\prime}(2\bar{s}-s) \Big] f_H ds \\
& + \int_{\bar{s}}^{\infty} \Big[ u'(\kappa(x(\mu^*(s))), H)\kappa'(x(\mu^*(s)))\mu^{*\prime}(2\bar{s}-s) - u'(\kappa(\mu^*(s)), L)\kappa'(\mu^*(s))\mu^{*\prime}(s) \Big] f_L ds \\
> & \ 0
\end{aligned}$$

where we have denoted $f_\theta := f(s|\theta + i^*_\theta)$ for $\theta = H, L$. In the above, the last inequality follows because for all $s$ for which the integrand of the second integral is negative, the integrand of the first integral is larger in absolute value (since $u'(k, H) > u'(k, L)$) and $f(s|H + i^*_H) > f(s|L + i^*_L)$. Given $c'' > 0$ and (6), this proves part (a) of Proposition 2. Parts (b) and (c) can be proved analogously. ∎

**Proof of Proposition 3**: For all $d \geq \Delta$ and $i_L \geq 0$, recall that $BR_\theta(i_L + d, i_L)$ is nonempty and bounded above by $M$. Let $FP_L(d) = \{i_L \in [0, M] | i_L \in BR_L(i_L + d, i_L)\}$ and $FP_H(d) = \{i_L + d \in [d, M] | i_L + d \in BR_H(i_L + d, i_L)\}$.

Claim 1 $FP_L(d)$ is nonempty and upper semi-continuous in $d \in [\Delta, M]$.

Given $d \geq \Delta$, as $i_L$ increases, the graph of $\mu(s|i_L + d, i_L)$ as a function of $s$ shifts to the right by the same amount and consequently, $U_\theta(i|i_L + d, i_L) := \int u(\kappa(\mu(s|i_L + d, i_L)), \theta) f(s|\theta + i) ds$ also shifts, as a function of $i$, to the right by the same amount. Hence, $U_\theta(i|i_L + d, i_L) = U_\theta(i - i_L|d, 0)$. By assumption, $BR_L(i_L + d, i_L)$ is convex and closed. Let $i' = \min BR_L(i_L + d, i_L)$. For $i_L + \epsilon > i_L$, as $U_\theta(i|i_L + \epsilon + d, i_L + \epsilon) = U_\theta(i - \epsilon|i_L + d, i_L)$ we deduce for $i > i' + \epsilon$ that $U_\theta(i - \epsilon|i_L + d, i_L) - c(i - \epsilon) - U_\theta(i|i_L + \epsilon + d, i_L + \epsilon) + c(i) = c(i) - c(i - \epsilon)$ which increases in $i$. Thus, $BR_L(i_L + \epsilon + d, i_L + \epsilon) \cap (i', M] = \emptyset$. That is, $BR_L(i_L + d, i_L)$ is "non-accelerating" in the sense that $\min BR_L(i_L + d, i_L) + i'_L - i_L \geq \max BR_L(i'_L + d, i'_L)$ for $i_L < i'_L$. This further implies that $FP_L(d)$ is a closed interval with the property that $\min BR_L(i_L + d, i_L) > i_L$ for $i_L < \min FP_L(d)$ while $\max BR_L(i_L + d, i_L) < i_L$ for $i_L > \max FP_L(d)$. As $BR_L(i_L + d, i_L) \subset [0, M]$, together with the closed graph of $BR_L(i_H, i_L)$, this property implies that $FP_L(d)$ is upper semi-continuous in $d \in [\Delta, M]$ with value strictly above 0.

Claim 2 $FP_H(d)$ is nonempty and upper semi-continuous for $d \in [\Delta, M']$ where $M' < M$ and $M' \in FP_H(M')$.

By the same argument as above, $BR_H(i_L + d, i_L)$ is non-accelerating in the sense described above. Together with the closed graph of $BR_H(i_H, i_L)$, this property implies that $FP_H(d)$ is upper semi-continuous at $d$ if $FP_H(d) \neq \emptyset$. Since $FP_H(\Delta) \neq \emptyset$, by the same reasoning as above, there exist $M'$ such that $FP_H(d)$ is nonempty and upper semi-continuous for $d \in [\Delta, M']$ with $M' \in FP_H(M')$. From $FP_H(d) \in [d, M)$ it follows that $M' < M$.

By Claims 1 and 2, there exist $d^* \in (\Delta, M')$ and $(i_H^*, i_L^*) \in FP_H(d^*) \times FP_L(d^*)$ such that $i_H^* - i_L^* = d^*$. By definition of $FP_\theta$, $i_\theta^*$ is the optimal influence activity level under the state $\theta$ conditional on the HQ's best response to $(i_H^*, i_L^*)$, completing the proof. ∎

**Deferred discussion on $BR_\theta(i_H, i_L)$ in Example 1**: Assume $\kappa(1) < c(1/2)$ so that $M < 1/2$. (So long as $\kappa(1) < c(1)$, the argument below can be modified to the same effect.) It suffices to show that $BR_\theta(i_H, i_L)$ is a continuous function on $I := \{(i_H, i_L) \in [0, 1/2]^2 | i_H \geq i_L\}$. Given $(i_H, i_L) \in I$ with $d = i_H - i_L \in [0, 1/2]$, the posterior is $\mu(s) = (s - i_L - d)/(1 - d)$ for $s \in [i_L + d, i_L + 1]$ while $\mu(s) = 0$ for $s < i_L + d$ and $\mu(s) = 1$ for $s > i_L + 1$. Hence, $\mu'(s) = 1/(1 - d)$ for $s \in [i_L + d, i_L + 1]$ and 0 for all other $s$.

As a preliminary step, assume $\kappa'$ is constant, say $\eta > 0$, then for each $\theta$ the marginal utility from influence activity level $i$ is 0 for low $i$ such that $\theta + i + 1 < i_L + d$; is

$$MU_\theta(i|i_H, i_L) := \frac{\eta}{1 - d} \int_{i_L + d}^{i_L + 1} f(s|\theta + i) ds$$

if $i_L + d < \theta + i + 1 < i_L + 3$; and is 0 again for higher $i$ such that $i_L + 3 < \theta + i + 1$. It is straightforward to verify that the derivative $MU_\theta'(i|i_H, i_L)$ increases linearly from 0 in $i \in (i_L + d - \theta - 1, i_L + 3 - \theta - 1)$ until the midpoint then decrease symmetrically to 0. That is, $MU_\theta''(i|i_H, i_L) = \eta/(1 - d)$ for the first half of this interval (and $-\eta/(1 - d)$ for the latter half). If $c$ is more convex in $i \in (0, 1/2)$ for any $d \in (0, 1/2)$, i.e, $c''(i) > 2\eta$, then (i) if $0 \leq i_L + d - \theta - 1$ then $BR_\theta(i_H, i_L) = \{0\}$, and (ii) if $i_L + d - \theta - 1 < 0$ then there is $\hat{\imath}_\theta \in (0, 1/2)$ such that $MU_\theta(\hat{\imath}_\theta | i_H, i_L) = c'(\hat{\imath}_\theta)$ while $MU_\theta(i|i_H, i_L) > c'(i)$ for $i < \hat{\imath}_\theta$ and $MU_\theta(i|i_H, i_L) < c'(i)$ for $i > \hat{\imath}_\theta$, so that $BR_\theta(i_H, i_L) = \{\hat{\imath}_\theta\}$. As $\hat{\imath}_\theta$ is continuous, $BR_\theta(i_H, i_L)$ is a continuous function on $I$ as desired.

Note that $\kappa'$ affects $MU_\theta(i|i_H, i_L)$ in a continuous manner. Thus, if $\kappa'(\mu)$ is sufficiently close to $\eta$ at all $\mu \in (0, 1)$ so that the condition continues to hold that $c''(i)$ exceeds $MU_\theta''(i|i_H, i_L)$ uniformly, then an analogous argument establishes that $BR_\theta(i_H, i_L)$ is a continuous function on $I$. ∎

**Proof of (10):** Differentiating (9) with respect to $\mu$, we obtain

$$\frac{d\kappa}{d\mu} = -\frac{\Delta y'}{Ey''} > 0 \tag{A3}$$

since $\Delta y' > 0$ and $Ey'' < 0$. Differentiating (A3) once more leads to

$$\frac{d^2\kappa}{d\mu^2} = \frac{1}{(Ey'')^2}\left[\Delta y' \frac{dEy''}{d\mu} - Ey'' \frac{d\Delta y'}{d\mu}\right]. \tag{A4}$$

From (A3), we have $dEy''/d\mu = \Delta y'' - \Delta y'(Ey'''/Ey'')$ and $d\Delta y'/d\mu = -(\Delta y' \Delta y'')/Ey''$. Substituting these into (A4) and arranging terms, we obtain

$$\frac{d^2\kappa}{d\mu^2} = \frac{\Delta y'}{(Ey'')^2}\left[2\Delta y'' - \Delta y' \left(\frac{Ey'''}{Ey''}\right)\right].$$

From the above follows (10). ∎

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