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Guido Friebel and Michael Raith

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STRATEGIC RECRUITING AND THE CHAIN OF COMMAND: ON THE ABUSE OF AUTHORITY IN INTERNAL LABOUR MARKETS

Guido Friebel, IDEI, SITE, Stockholm, ECARES and CEPR
Michael Raith, GSB University of Chicago and CEPR

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: http://www.cepr.org

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ABSTRACT

Strategic Recruiting And The Chain Of Command: On The Abuse Of Authority In Internal Labour Markets *

If managers and their subordinates had the same basic qualifications, organizations could benefit from replacing unproductive superiors with more productive subordinates. This threat of being replaced, however, could give rise to *strategic recruiting*: Unproductive superiors might deliberately recruit unproductive subordinates in order to protect themselves, or engage in other forms of abuse of authority which could be harmful to the organization. We show that the common practice of requiring intra-firm communication to pass through a *chain of command* can be an effective way to secure the incentives for superiors to recruit the best possible subordinates. We discuss some alternative instruments and general implications of our analysis for organizational design.

JEL Classification: D82, J41, M12
Keywords: hierarchies, strategic recruiting, internal labour markets, abuse of authority, chain of command

Guido Friebel
IDEI
Université des Sciences Sociales de Toulouse
Place Anatole-France
F31042 Toulouse CEDEX
FRANCE
Tel: (33 5) 61 12 85 89
Fax: (33 5) 61 12 86 37
Email: guido.friebel@hhs.se

Michael Raith
Graduate School of Business
University of Chicago
1101 E. 58th Street
Chicago, IL 60637
USA
Tel: (1 773) 702 7324
Fax: (1 773) 702 0458
Email: michael.raith@gsb.uchicago.edu

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NON-TECHNICAL SUMMARY

The chain of command is one of the classical principles of management science. It stipulates that orders and the flow of information between any non-adjacent levels in a hierarchy have to pass through a well-defined chain of intermediate levels. In the past decades, many management theorists have argued that organizational forms building on the chain-of-command principle obstruct the employees' motivation and inhibit firms' flexibility. However, it appears that many organizations are maintaining rather hierarchical communication patterns. Moreover, experiments with looser organizational forms such as open-door policies, or '360 degree' performance reviews, in which subordinates evaluate their superiors, often fail to yield a smoother flow of information and higher degrees of organizational flexibility. Rather, these changes often meet fierce resistance by middle managers and create intra-organizational conflicts.

We argue that the persistence of hierarchical communication may be due to the fact that it can prevent intra-organizational conflicts that can emerge in firms that utilize internal labour markets. Here, higher wages and additional benefits accompany positions at higher levels in the hierarchy. Hence, subordinates may want to strive for the position of their immediate supervisor. A subordinate may try to inform the top management about the fact that he or she is better suited for the position than the immediate supervisor. When the superior sees his position in the firm jeopardized, or anticipates such a danger, there is a risk that he abuses his personnel authority. He may engage, for instance, in 'strategic recruiting', i.e. deliberately seek recruitment of a weaker, but less dangerous candidate, or deliberately not develop employees under his purview. This can entail substantial costs for the firm. Not only does this decrease the productivity of the units affected, but such behaviour also jeopardizes the function of the internal labour market as a screening device.

The argument is captured in a model that considers a project jointly realized by a middle manager and his subordinate, a bottom manager. They have the same basic qualifications and it is hence possible to replace the middle with the bottom manager. A top manager interested in output maximization decides after a first period of production whether to keep the middle manager employed, based on two types of information. First, the joint output is observed. Second, if the bottom manager is productive and the middle manager is unproductive, the former may try to inform the top manager about this fact, expecting to be promoted as a consequence. The ability to communicate this information to the top manager depends on how open the communication channel between the bottom manager and the top manager is, or in other words, to what extent a chain of command is followed.

The middle manager faces a conflict when recruiting his subordinate: Having a productive collaborator increases the expected joint productivity of the team and hence the middle manager's odds of staying in his job because of good performance, but also exposes him to the risk of being replaced by his subordinate. This risk is larger the more open the communication channels are, thus leading to a reduced effort to find a good subordinate, up to the point that the middle manager may actively seek to hire an unproductive, and therefore unthreatening, subordinate.

The firm, then, faces a trade-off regarding the optimal degree of openness of communication: open communication facilitates the detection of unproductive middle managers provided that the bottom manager is productive, but at the same time may induce the middle manager to engage in abuse of his personnel authority. We show that completely open communication can be optimal only if at least one of the following conditions are met: Either top management must have some control over the middle manager's recruitment decision; future production must be more important to the firm than present production; or there must be benefits to open communication that are not related to the detection of incompetent middle managers. Otherwise, restricted communication, either in the form of total or partial enforcement of the chain of command, is optimal.

Our model has a number of empirical predictions on the determinants of the openness of intra-firm communication. First, it has been argued that firms shift away from internal labour markets with back-loaded wages to more market-based wage structures. Our model predicts that such shifts will go along with more open communication structures. The same is true for firms in which direct supervisors share the recruiting and personnel authority with other members of the organization. Moreover, firms for which it is easier to recruit junior personnel and that have better access to qualified middle managers, should also tend to more open communication structures. The model thus highlights that there are complimentarities between the communication structure and the personnel policies of firms that have, to date, not been considered.

1 Introduction

"Let me have men about me that are fat;
Sleek-headed men and such as sleep o' night;
Yond' Cassius has a lean and hungry look;
He thinks too much: such men are dangerous"

William Shakespeare: *Julius Caesar*

"One of your jobs as a manager is to identify and promote new managers. Ideally, each new manager should be less qualified than you. Otherwise that new manager will try to take your job or make you look dumb. It's in your best interest to keep the talent pool as thin as possible, just as the people who promoted you have done..."

Dogbert's Top Secret Management Handbook (Adams 1996)

Many firms allocate employees to jobs through internal labor markets. Often, employees entering share the same initial qualifications such as education and general skills. Over time, the firm learns about the productivity of employees, and more senior posts are filled from within by the promotion of people from lower levels. Promotions are often associated with substantial increases in wages and private benefits. In such situations, subordinates may try to obtain the job of their superior, for instance by signaling to the top management that they are better suited for the job than her direct boss. In this sense, there is *vertical competition* between subordinate and supervisor for the latter's position.

Anticipating the risk of replacement, supervisors can abuse their authority in various ways in order to retain their jobs. The most prominent form of abuse of authority occurs when supervisors deliberately seek to hire subordinates who are less productive and hence less dangerous to them, even if this reduces the performance of the sub-unit they are responsible for. Such *Strategic recruiting* can entail substantial costs for the organization. In addition to decreasing the productivity of the units affected, it jeopardizes the function of the internal labor market as a screening device. Ultimately, strategic recruiting can lead to "multiple weak links" (South and Matejka 1990), because strategically recruited unproductive managers tend to engage in strategic recruiting themselves (cf. Dilbert-quote above).

This paper investigates organizational responses to this problem. In particular, we show that the common practice of enforcing a "Chain of command", i.e. restricting or prohibiting communication between a subordinate and her manager's own superior (also called 'skip-level reporting'), can be an effective way to secure a manager's incentive to recruit the best possible subordinates.[1]

The argument, captured in our model (Section 2), goes as follows. Consider a project that is jointly realized by a middle manager and his subordinate, a bottom manager. Both originate from the same pool (comprising people of high or low ability). Hence it is possible to replace the middle by the bottom manager. A top manager interested in output maximization decides after a first period of production whether to keep the middle manager employed, based on two types of information. First, she observes the joint output. Second, if the bottom manager is productive and the middle manager is unproductive, the former may try to inform the top manager about this fact, expecting to be promoted as a consequence. The ability to communicate this information to the top manager depends on how open the communication channel between the bottom manager and the top manager is, or in other words, to what extent a chain of command is followed.

The middle manager faces a conflict when recruiting his subordinate: Having a productive collaborator increases the expected joint productivity of the team and hence the middle manager's odds of staying in his job because of good performance, but also exposes him to the risk of being replaced by his subordinate. This risk is larger the more open the communication channels are, thus leading to a reduced effort to find a good subordinate, up to the point that the middle manager may actively seek to hire an unproductive and therefore unthreatening subordinate.

The firm, then, faces a tradeoff regarding the optimal degree of openness of commu-

[1] In general, under a "chain of command" rule (cf. Fayol 1916), both orders and the flow of information between any two non-adjacent levels in a hierarchy have to pass through a well-defined chain of intermediate levels. Here, we focus on the practise of restricting a subordinate's ability to communicate with anyone in the hierarchy above her immediate superior.

nication (cf. Section 3): open communication facilitates the detection of unproductive middle managers *provided* that the bottom manager is productive, but at the same time undermines the middle manager's incentive to hire a productive subordinate in the first place. Depending on all parameters of the model, either open communication, complete enforcement of a chain of command, or some intermediate degree of openness of communication can be optimal.

Completely open communication can be optimal only if at least one of the following conditions are met: Top management must have some control over the middle manager's recruitment decision; future production must be more important to the firm than present production; or there must be benefits to open communication that are not related to the detection of incompetent middle managers.

The comparative statics lead to the following predictions: (a) The optimal degree of openness is decreasing in the rents the middle manager earns in his position. Thus, a shift from an internal labor market with backloaded wages to more market-based wages tends to go along with more open skip-level communication. (b) The optimal degree of openness is increasing in the level of control the top manager exerts over the middle manager's recruiting decisions. Thus, firms in which several people are involved in recruiting and development decisions for a given employee will tend to have more open communication. (c) The optimal degree of openness is constant or increasing in the costs of recruiting a good bottom manager. (d) If open communication is sufficiently desirable for reasons other than the detection of unproductive managers, the optimal degree of openness is increasing in the firm's ability to select productive middle managers who have nothing to fear from productive subordinates. These results highlight that there are complementarities between a firm's internal communication structure and its personnel policies.

In Section 4, we analyze how the chain of command compares to other instruments that can alleviate problems of vertical competition. If output is verifiable, the firm can insure the middle manager by paying him *severance* if he is replaced by his subordinate despite good performance by the team. It turns out that whether restricting communication is optimal depends on the rents associated with the position of the middle manager. If they are rather small, a severance pay will suffice to prevent strategic recruiting. Otherwise, our previous results hold; i.e. it is optimal to restrict or prohibit skip-level communication.

Organizations can prevent strategic recruiting by *limiting a line manager's influence* over recruiting decisions in some cases. In general, however, the manager's input in the selection of his own subordinate is essential. Moreover, even when strategic recruiting can be prevented, there remain numerous other ways for middle managers to defend themselves against more productive subordinates. In particular, they can decide not to develop their subordinates' skills, pass on unfavorable information about them, and so forth. The problem hence continues to exist, albeit in a slightly different form.

More effective, but also more rigid, is the *design of career paths* through promotion rules. Promotion by seniority and "non-replacement" rules can reduce the incentive of managers to abuse their authority, because they directly prevent vertical competition. This was first observed by Doeringer and Piore (1971), who point out that experienced workmen are in the position to frustrate on-the-job training by younger workers if these later threaten their position. Similar remedies have been suggested in other contexts in which distortions in a manager's evaluation of his subordinates play an important role. These include the theory of influence activities due to Milgrom (1988) and Milgrom and Roberts (1990) and Prendergast and Topel's (1996) analysis of favoritism. However, in those theories the distortions (only) result from a manager's personal preferences or his susceptibility to influence activities. In contrast, in our theory, his job is at stake, which provides strong incentives to fend off contestants in a strategic way. This is also why, as our analysis shows, a manager's responsibility for the performance of his unit does not automatically ensure the incentive to recruit the best possible subordinates.[2]

Even though strategic recruiting or the possibility thereof is a widespread phenomenon,

[2] In contrast, the notion that behavior that does not fall in line with the firm's interests can be effectively prevented by tying a manager's compensation to his unit's performance appears e.g. in Prendergast and Topel (1996) and Fairburn and Malcolmson (1997). To be precise, the problem is always solved if a manager is a full residual claimant to his actions. This is not, however, the case if the manager's compensation or job depends on output, but if he does not receive the surplus created if he is replaced by a more productive subordinate.

it has so far hardly received any attention in the academic literature. An exception is Carmichael (1988), who interprets tenure in academia as a device to protect senior faculty members from replacement by assistant professors, which is needed to induce senior faculty to recruit the best possible juniors. However, lifetime employment is only rarely found in private businesses, as the adverse effects on employees' incentives are bound to be very costly. While we identify the same basic problem as Carmichael, the organizational response we emphasize is very different from his. In our simple model, which disregards the choice of effort in production, we show that, unless open communication is strongly preferred for other reasons, a chain of command is superior to an employment guarantee for the middle manager. This is because the chain of command remedy still allows the top manager to fire a middle manager if his team's performance is substandard.

To our knowledge, our paper is the first to analyze optimal communication in a multi-tier hierarchy from an incentive-theoretical point of view. Of course, hierarchical information flows may also be desirable to ensure that no contradictory information is generated, and to avoid "information overload" at higher levels in the hierarchy (cf. Bolton and Dewatripont 1994). In our view, the incentive-based theory presented here and theories based on information processing are complementary explanations for restrictions of intra-firm communication. However, it is often the by-passed superior and not the higher-level manager who complains when a subordinate violates the chain of command. Similarly, organizational changes toward more open communication often meet the resistance of middle management who see their authority undermined. These observations are difficult to explain in terms of information processing, but follow naturally from our theory.

2 The model

We consider an organization that consists of three individuals in a hierarchical relationship: a top manager ("T", female), a middle manager ("M", male), and a bottom manager ("B", female). An informal overview of the game is as follows:

- T hires M. Subsequently, M hires B. Thus, we assume that T has delegated decisions regarding B to M, either because of time constraints or M's greater expertise. The effort M chooses in recruiting B depends on his own productivity.

- M and B produce some output y as a team. T observes this output, but not the individual contributions of M or B. At the same time, B may try to inform T about her and M's individual productivities, depending on how much communication between B and T the organization allows.

- We assume that the team's output is unverifiable, so that M and B receive a fixed compensation independent of output. T is concerned about the long-run productivity of the (M,B)-team and may wish to replace the current M, depending on the team's output and information she might receive from B. Specifically, T can either retain M, hire a new M from outside, or fire M and promote B to M's position. We assume that M's payoff exceeds that of B, as well as that of any outside occupation, which implies that M prefers to keep his job, while B would like to be promoted.

- The new (M,B)-team produces a second-period output.

2.1 Timing

The sequence of events is listed in Table 1. Notice that while our organization has three members, only T and M are players in a game-theoretic sense, who each choose one action in the course of the game. All other moves in the game are dominant actions.

1. T hires M. With probability α_0, M is productive ("good"), and with probability $1 - \alpha_0$, he is unproductive ("bad"). "Good" and "bad" refer to the quality of the match between a person and the job in question, which is unknown to M at the time of recruitment.

2. M learns his type.

3. M hires B. He chooses a recruiting effort $\alpha \in [0, 1]$, whereupon he draws a good B with probability α and a bad one with probability $1-\alpha$. The costs of recruiting consist of first, a direct search cost $k_0\alpha^2$ (with $k_0 > 0$) that is increasing in α. Second, there is a cost

Table 1: Timing of events

Period 1	1.	T hires M.	
	2.	M learns his type.	
	3.	M hires B.	*(M's action)*
	4.	M and B learn each other's type.	
	5.	First-period output is realized.	
	6.	B signals productivities to T.	
Period 2	7.	T retains or replaces M.	*(T's action)*
	8.	M retains or replaces B.	
	9.	Second-period output is realized.	

$k_1(1-\alpha)^2$ (with $k_1 \geq 0$) of getting T's approval for the candidate M chooses. This cost is *decreasing* in α: It is easy for M to get T's approval for a candidate with outstanding credentials, whereas M incurs costs in persuading T that an apparently weaker candidate is indeed suitable for the B-position. The parameter k_1 measures the extent of T's control over M's recruiting decisions. Thus, M's recruiting costs are

$$C(\alpha) = k_0\alpha^2 + k_1(1-\alpha)^2. \tag{1}$$

For future reference, denote the optimal effort levels chosen by a good and a bad M as α_g and α_b, respectively.

4. Through team production, M and B get to know each other's type.

5. M and B jointly produce the first-period output y. This output is random and takes the values 0 or 1. For simplicity, we disregard any moral-hazard problems related to production. Rather, the probability of $y = 1$ only depends on the productivities of M and B. Let $q_{gg} = \text{Prob}\{y = 1|\text{ M=good and B=good}\}$, and define q_{gb}, q_{bg} and q_{bb} analogously. Thus, the firm's technology is completely characterized by the vector $\mathbf{q} = (q_{gg}, q_{gb}, q_{bg}, q_{bb})$.

We assume that $q_{gg} \geq q_{gb} \geq q_{bg} \geq q_{bb}$. Here, the first and the last inequalities reflect the assumption that the expected output is an increasing function of the productivities of M and B. M's superior rank compared with B is reflected in the second inequality: M is at least as important for production as B in the sense that a (M=g, B=b) team is at least as productive as a (M=b, B=g) team. Moreover, we assume that M's and B's productivities are complementary: $q_{gg} - q_{gb} \geq q_{bg} - q_{bb}$. That is, having a good B as partner instead of a bad one is more valuable to a good M than to a bad one.[3]

6. B signals productivities to T. If the team is of the form (M=b, B=g), B can send a signal to T which perfectly reveals the type of the production team without cost and in a credible way. However, this information reaches T only with a certain probability $\phi \in [0, 1]$. Here, ϕ captures the openness of skip-level communication between B and T: $\phi = 1$ represents completely open communication; $\phi = 0$ corresponds to the strict enforcement of a "chain of command". While ϕ is exogenous to the game between T and M, we discuss in Section 3.2 how an organizational planner would choose ϕ. In the conclusion, we address implementation issues.

Put in formal terms, T receives a signal z which can take the value 'c' (types are concealed) or 'd' (types are disclosed). If 'c' is received, this may be either because the production team is *not* of the form (M=b, B=g) or because B's signal did not get through to T. Since B can never lose, but possibly gain (by being promoted), from signaling her superior type to T, it is always optimal for B to send a signal.

Remark: We assume that B is able to provide some evidence of her superior productivity. We also assume that B cannot credibly claim that she is good or M is bad in any absolute sense, while she is able to prove that she is *better than* M.[4]

As an illustration of these assumptions, consider an investment project such as the purchase of securities. Suppose B proposed the purchase of one type, but M decided to buy

[3] In Kremer's (1993) "O-ring" model, team productivity is given by the *product* of the abilities of the team's members. Our production technology includes this specification as a special case.

[4] This assumption is familiar from the literature on rank-order tournaments, cf. Lazear and Rosen (1981). In fact, restricting the credibility of B's assertions to comparisons with M seems to be a necessary part of the story. In contrast, suppose that whenever *M is bad*, any B, good or bad, could let T know about M's low productivity. Then M would not be able to protect himself by hiring a bad B. As there is ample evidence of strategic recruiting as a real-world phenomenon, this implication indirectly justifies our assumption. Second, suppose that whenever *B is good*, she could try to inform T about this fact, independently of M's type. But here it turns out that a good M, too, might deliberately recruit a bad B, just as a bad M, a prediction which does not seem very appealing either.

another type. Then, B can ex post prove through memos or other internal documents that profits would have been higher if M had followed her suggestion. Such a proof, however, does not imply that her suggestions were actually profit-maximizing.

7. T retains or replaces M. Upon observing the realizations of y and z, T chooses to either retain the current M, fire the current M and hire a new one from outside, or fire M and promote B. Clearly, promotion is a relevant option only if B is to some extent eligible for the job of M. For simplicity, we assume that a promoted B retains her type, i.e. she is good as an M if and only if she was good as a B.[5] For the model to be well-behaved, we need to make the following assumption about α_0, T's recruiting effort:

$$\alpha_0 \geq \alpha_0 \alpha_g + (1 - \alpha_0)\alpha_b. \tag{2}$$

The expression on the right-hand side is T's ex-ante expectation that a B chosen by M is good. It guarantees that, absent any additional information, T prefers to hire M herself than to immediately promote a B recruited by M. In other words, T wants to promote B only if she has good news about her. (In Section 3.1, we express α_g and α_b in terms of the exogenous parameters of the model.)

8. M retains or replaces B. This is not a strategic decision, because it does not affect M's payoff in any way. If M is a promoted B (such that the B-position is vacant), M hires a new B with some effort $\alpha_n \geq \alpha_0$, which is exogenous. A retained M, who knows B's type, acts in the firm's interest and retains B if she is good and hires a new B (with effort α_n) if she is bad. If a new M is hired, the previous M informs the new one about B's type before leaving the firm. Therefore, the new M decides in exactly the same way.[6]

9. The second-period output is realized.

[5] Alternatively, we could assume that a person who is good as a B is also good as an M with some probability β □ 1. None of our results change under this weaker assumption, except that we need to specify a lower bound to β, or else T might never promote B even if she is certain that B is good.

[6] Here, we rule out that upon dismissal, M takes revenge on the firm by deliberately misinforming his successor.

2.2 Payoffs

In the first period, M and B receive a fixed compensation r_M and r_B, respectively. We assume that $r_M > r_B > 0$. Moreover, if M is fired after the first period, M receives r_B elsewhere, i.e. he is effectively demoted to a B-position. Hence, M strictly prefers keeping his job to losing it (and B strictly prefers promotion over staying in her job).[7] Consequently, M chooses α to maximize his discounted second-period payoff, net of his recruiting costs:

$$U(\alpha) = r_M - C(\alpha) + \delta[P_{ret}(\alpha)r_M + (1 - P_{ret}(\alpha))r_B], \tag{3}$$

where $P_{ret}(\alpha)$ is the probability that M is retained, as a function of α and his own type; and δ is the discount factor.

Our assumption that neither y nor z are verifiable rules out explicit incentive contracts. In Section 4, however, we relax this assumption to discuss the use of monetary incentives. We also do not consider compensation schemes which make M indifferent between keeping and losing his job.[8] Finally, we also rule out that the (M,B)-unit of the firm is sold to M, i.e. that M becomes the residual claimant of this unit. The essential element of all these assumptions is: M is strictly worse off if he loses his job or is demoted.

T maximizes the firm's profit, i.e. the expected present value of outputs produced in the two periods (where the value of $y = 1$ is normalized to 1), net of the monetary compensation for M and B. In addition, we allow in our model that there are positive effects of open communication unrelated to the detection of bad Ms.[9] To capture this idea without modeling these benefits explicitly, we assume that the firm's expected profit increases in ϕ at some rate $\omega \geq 0$.

Formally, T's beliefs about the composition of the (M,B)-team are characterized by

[7] In our analysis, only M's loss if he is fired, $r_M - r_B$, is of interest, whereas B's payoff itself is not. We could therefore consider any other reservation payoff smaller than r_M.

[8] The reasons are the same for assuming $r_M > r_B > 0$: efficiency wages, deferred compensation as an incentive to make specific investments, promotions as tournaments etc.

[9] The recent business literature often advocates open communication between employees of different ranks, emphasizing the advantages of a free flow of ideas within firms.

a probability distribution over the four possible teams (g,g), (g,b), (b,g), and (b,b). Let (the quadruple) $\mathbf{p_1}$ denote T's beliefs about the team in the first period, and let E($\mathbf{p_2}$) be her expected beliefs in period 2. Here, $\mathbf{p_2}$ is the T's belief at the beginning of period 2, which is why we take the expected value in looking at the ex-ante expected profit. Then the firm's expected profit can be written as

$$\pi = \mathbf{p_1}\mathbf{q} + \delta E(\mathbf{p_2})\mathbf{q} + (1+\delta)\omega\phi - (1+\delta)(r_M + r_B). \tag{4}$$

Here, we treat the benefits r_M and r_B as actual monetary payments by the firm, but this does not affect our results in any significant way. The second period might represent a discounted future in which no further changes in employment occur, and might therefore be relatively more important than the first period. Therefore, we allow that $\delta > 1$.

3 Analysis of the model

In this section, we derive the equilibrium for the game between T and M described above. Then (3.2), we analyze how an organizational planner would optimally choose the level of openness ϕ, and look at how it varies with changes in the parameters of the model (3.3).

3.1 Equilibium

In its reduced form, the game described in Section 2 is a simple sequential game involving M and T with incomplete information on part of T: There are two types of Ms, good ones and bad ones. T knows the distribution of types (given by α_0) but cannot directly observe the type of M she hires. M chooses an unobservable recruiting effort (α_g and α_b, respectively). Based on observable but non-verifiable signals (the team's output and B's communication with T), T chooses to retain M, hire a new one, or promote B.

By choosing particular values for the model parameters, one can construct equilibria in which T does not make any use of the output signal y when making a decision about M. However, these equilibria do not lead to any interesting insights for the situation we analyze. Hence, in following result, we impose a simple parameter constraint which ensures the existence and uniqueness of a non-trivial Bayesian Nash equilibrium. Further below, we discuss how a degenerate equilibrium can arise if this constraint does not hold.

Proposition 1 *If $q_{gg} = 1$, there exists a unique Bayesian Nash equilibrium in which (i) a good M chooses recruiting effort*

$$\alpha_g = \frac{2k_1 + \delta(q_{gg} - q_{gb})(r_M - r_B)}{2(k_0 + k_1)}$$

(with lower and upper bounds 0 and 1, respectively),(ii) a bad M chooses recruiting effort

$$\alpha_b = \frac{2k_1 + \delta((1-\phi)q_{bg} - q_{bb})(r_M - r_B)}{2(k_0 + k_1)},$$

and (iii) upon observing

- $z = d$*: T promotes B*
- $z = c$ *and* $y = 0$*: T hires a new M*
- $z = c$ *and* $y = 1$*: T retains M*

All proofs are in the Appendix. It is important to note that $q_{gg} = 1$ is a sufficient, but not necessary condition for the existence and uniqueness of the equilibrium described in Proposition 1. The precise necessary and sufficient condition is stated in the proof.

To understand *T's best response* to M's strategy, consider the effects of the signals y and z on T's updated belief that M is good. First, upon observing $y = 1$, T's posterior about M exceeds her prior, while if $y = 0$, the opposite is the case. Second, if $z = d$, T knows for sure that M is bad. This in turn implies that $z = c$ is good news about M.

Hence, if $z = d$, T promotes B because a good M is more valuable than a good B. If $z = c$ and output is high, T retains M rather than to promote B, since both signals are not only good news about M in absolute terms, but also relative to B.

A complication arises when $y = 0$ and $z = c$. While low output is *bad* news about M, observing $z = c$ is *good* news about him. Hence, T's best response could be to retain M rather than to fire him, a situation which appears unrealistic and leads to a trivial equilibrium where M is only fired if T has received B's signal.

The restrictions that we impose imply that even with completely open communication (in which case $z = c$ is most informative), the team's output is more informative about M's productivity than $z = c$. They ensure that the probability of high output of a good M is sufficiently high. This in turn means a low output is sufficiently bad news about M to outweigh the positive effect of $z = c$ on T's updated belief. With this assumption, if $z = c$ and $y = 0$, T does not retain M. Moreover, the lower bound that we imposed on α_0 implies that T prefers to hire a new M rather than to promote B.

M's best response is to choose the α that maximizes his payoff (3), anticipating T's response to y and z. A good M (for whom always $z = c$) is retained if and only if $y = 1$. Thus, the probability of being retained is $P_{ret}(\alpha) = \alpha q_{gg} + (1 - \alpha) q_{gb}$, and plugging this expression into (3) leads to the expression for α_g stated in the proposition.

A bad M, in contrast, is fired whenever $y = 0$, but also if $z = d$, which happens with probability ϕ if B is good. Hence, the probability of being retained is $P_{ret}(\alpha) = \alpha(1 - \phi) q_{bg} + (1 - \alpha) q_{bb}$, which leads to the expression for α_b in Proposition 1.

Comparing α_g and α_b, we find that for any ϕ, a bad M chooses a lower recruiting effort than a good M, for two reasons: 1. Because of our complementarity assumption, a good B is less valuable to a bad M than to a good M. 2. A bad M faces a risk of being replaced by a good B, which further reduces M's incentive to find a good B. His effort α_b is decreasing in ϕ: more open communication between B and T exposes M to greater risk and therefore increases his incentive to deliberately recruit a bad B. Notice also that when $\phi \geq 1 - q_{bb}/q_{bg}$, M actively engages in strategic recruiting in the sense of choosing an α below the level that minimizes $C(\alpha)$: Here, M's risk of being exposed by a better B is so large that M prefers to incur the cost of getting T's approval in trying to hire a bad B. If, in contrast, T does not control M's recruiting decisions at all ($k_1 = 0$), then $\alpha_b = 0$ for any $\phi \geq 1 - q_{bb}/q_{bg}$.

Remark: We can now state condition (2) in terms of the exogenous parameters of the model by using the expressions in Proposition 1:

$$\alpha_0 \geq \frac{2k_1 + \delta(q_{bg} - q_{bb})(r_M - r_B)}{2(k_0 + k_1) - \delta(q_{gg} - q_{gb} - q_{bg} + q_{bb})(r_M - r_B)},$$

where the restriction $\alpha_g \square 1$ also guarantees that the lower bound to α_0 is at most 1.

3.2 Optimal choice of ϕ

An increase in the openness of communication has three different effects on the net profit of the firm (or unit), given by (4):

1. First, there is the direct benefit of a more effective detection of a bad M, if B can communicate more freely with T.

2. On the other hand, more open communication also exacerbates the negative effect of strategic recruiting: the larger ϕ, the smaller is the recruiting effort of a bad M, because of a greater risk of being revealed as bad by a good B.

3. Finally, there might be positive effects of open communication unrelated to the detection of bad Ms, which are captured by ω in the profit function.

Taken together, these three effects imply the following:

Proposition 2 *The firm's expected equilibrium profit is concave in ϕ.*

To see this, notice that ϕ affects the expected profit both directly (the first and third effects discussed above), and indirectly through α_b:

$$\frac{d\pi}{d\phi} = \frac{\partial\pi}{\partial\phi} + \frac{\partial\pi}{\partial\alpha_b}\frac{\partial\alpha_b}{\partial\phi}$$

Since expected profit is linear in ϕ, and α_b is a linear function of ϕ, the second-order derivative simplifies to $d^2\pi/d\phi^2 = (\partial^2\pi/\partial\alpha_b\partial\phi)\,(\partial\alpha_b/\partial\phi)$. The cross-derivative of π with respect to ϕ and α_b is positive: other things equal, a larger α_b increases the probability of having a team with a bad M and a good B in the first period, which in turn increases the firm's marginal value of detecting a bad M, and hence the marginal value of more openness. With α_b decreasing in ϕ, it then follows that expected profit is concave in ϕ.

Numerical examples satisfying the assumptions of the model and of Proposition 1 lead to the following

Observation: *The firm's profit $\pi(\phi)$ is either increasing, decreasing or hump-shaped in ϕ, implying that the firm's optimal level of ϕ is 0, 1, or takes an intermediate value in (0,1).*

While the precise conditions for each of these three cases involve rather awkward expressions, the following result indirectly shows what conditions are necessary for open communication ($\phi = 1$) to be optimal:

Proposition 3 *If $k_1 = 0$ and $\omega = 0$ and $\delta = 1$, then $\pi(0) > \pi(1)$; i.e. complete enforcement of a chain of command is more profitable than completely open communication.*

The implication of this result is that full openness can be optimal for the firm only if

(i) T exerts some control over M's recruiting decisions ($k_1 > 0$), or

(ii) future production (and hence detecting a bad M in period 1) is particularly valuable ($\delta > 1$), or

(iii) there is some benefit of openness unrelated to detecting bad Ms ($\omega > 0$).

3.3 Comparative Statics

We now analyze how changes in the parameters of the model affect the optimal level of openness.

Proposition 4 *The firm's optimal level of ϕ is (a) decreasing in $r_M - r_B$; (b) increasing in k_1; (c) increasing in k_0 if $\omega > 0$, otherwise independent of k_0; (d) decreasing in α_0 if $\omega = 0$, but increasing in α_0 if ω is sufficiently larger than 0; and (e) increasing in ω.*

Part (a): The difference $r_M - r_B$ affects the optimal ϕ through α_b. If $r_M - r_B$ decreases, α_b decreases in ϕ at a smaller rate. Trading off the benefits of openness and the loss due to strategic recruiting, T therefore chooses a larger ϕ. This result highlights a complimentarity between the firm's optimal communication structure and its internal labor market. Compensating M above marginal productivity ($r_M > r_B$) gives rise to strategic recruiting and therefore requires more restricted communication. In contrast, if wages are more market- (i.e. productivity-) based, there is less strategic recruiting, and the firm can allow more open communication. Our model thus predicts that a firm's transition from an internal labor market with backloaded wages to more market-based wages (for evidence of this trend, see Bertrand (1998)) allows more open skip-level communication within the firm.

Part(b): More control by T over M's recruiting decisions raises the costs of strategic recruiting and leads to higher levels of α_b for any ϕ. Strategic recruiting being less serious, a higher ϕ is optimal. Here, we only look at the effect of k_1 on ϕ. Clearly, increased control over M involves direct as well as indirect (e.g. by undermining M's authority) costs, putting a limit on the extent of control the firm wishes to exert.

Part (c): An increase in the costs of recruiting a good B leads to a direct decrease in (a bad) M's recruiting effort. The firm would want to compensate this by decreasing ϕ to provide better insurance to M. On the other hand, an increase in recruiting costs also makes M less sensitive to changes in ϕ, implying that the firm can afford to increase ϕ. When $\omega = 0$, these two effects cancel each other exactly. With $\omega > 0$, the second effect dominates, so that an increase in recruiting costs is accompanied by more openness.

A larger α_0 (part d) leads to smaller probability of recruiting a bad M. This has two effects: First, given α_b, T is now less concerned about strategic recruiting, which would suggest to increase ϕ. On the other hand, for the same reason (a lower probability of having a bad M), T's benefit from detecting a bad M decreases. If $\omega = 0$, i.e. without any other benefit of openness for the firm, this second effect outweighs the first, implying that an increase in α_0 leads to a decrease in the optimal ϕ. If, however, ω exceeds some minimal level, then the effect is reversed: A higher probability of recruiting a good M implies that the firm can now afford more openness. In this case, firms that spend more effort on recruiting can also afford more open communication, because good middle managers have less to fear from good subordinates. – Part (e) is obvious.

The effects of changes in δ, or a_n on the optimal ϕ are ambiguous. For example, an increase in δ makes detecting a bad M more important for the firm, which suggests an increase in ϕ. On the other hand, an increase in δ also raises the stakes for M and exacerbates strategic recruiting, which tend to reduce the optimal ϕ.

Similarly, the effects of changes in $\mathbf{q}$ on the optimal ϕ are ambiguous. An increase in q_{bg}, for example, affects the optimal ϕ in four different ways: First, it leads to an increase in α_b because a good B is now more valuable to a bad M. The optimal response to this effect would be to increase ϕ. Second, while the level of recruiting effort increases, $\partial\alpha_b/\partial\phi$ (which is negative) *decreases*, i.e. a change in ϕ has a stronger effect on α_b than before. This is because openness matters to a bad M only to the extent that he can be fired if $y = 1$, whereas if $y = 0$, he is fired anyway, which implies that the effect of ϕ on α_b depends on q_{bg}. This second effect offsets the first, leaving the direction of change for the optimal ϕ ambiguous. Third, q_{bg} affects the firm's marginal gain from more open communication, $\partial\pi/\partial\phi$, in uncertain direction. Finally, an increase in q_{bg} means that hiring a good B is not only more important to a bad M, but also to the firm, which induces the firm to decrease ϕ in order to increase a bad M's recruiting effort.

We have also looked at changes in the differences $q_{gb} - q_{bg}$ and $q_{bg} - q_{bb}$, but the results are ambiguous as well. An increase in $q_{gb} - q_{bg}$ tends to lead to an increase in the optimal ϕ (but not always), and an increase in $q_{bg} - q_{bb}$ tends to lead to a decrease ϕ (but not always).

4 Alternatives to the chain of command

In this section, we discuss alternative instruments that can be used to prevent strategic recruiting. First, we investigate the usefulness of monetary incentives (severance or bonus payments) when output is verifiable. Then, we discuss whether strategic recruiting can be prevented by limiting M's authority to select B. Finally, we look at how the firm can solve the problems addressed in this paper through the design of career paths.

4.1 Severance payments

T would never want to make an unconditional severance payment to M whenever she fires him, as this would only reward bad performance and thus reduce the incentives for both a good and a bad M to hire a good B. Strategic recruiting, however, only arises because a bad M can lose his job even if $y = 1$ (if B is good and reports $z = d$); whereas if $y = 0$, M is fired regardless of communication between B and T. Suppose, now, that the output

y is verifiable. Then T can offer a contract stipulating a severance payment s that is paid only if M is fired and $y = 1$. Such a contract insures a bad M against losing his job because of communication between B and T, without rewarding bad performance and without affecting a good M's recruiting incentives.[10] How does the feasibility of severance payments affect the firm's optimal communication structure?

If a bad M receives s if he is fired when $y = 1$, then his payoff changes from (3) to

$$U(\alpha) = r_M - C(\alpha) + \delta[P_{ret}(\alpha)r_M + (1 - P_{ret}(\alpha))r_B] + \alpha\phi q_{bg}s. \tag{5}$$

With P_{ret} unchanged (cf. Proposition 1), the resulting optimal recruiting effort α_b is

$$\alpha_b = \frac{2k_1 + \delta((1-\phi)q_{bg} - q_{bb})(r_M - r_B) + \phi q_{bg}s}{2(k_0 + k_1)}.$$

Thus, α_b is increasing in s for any ϕ and any $s > 0$. With a severance payment, a bad M has less to lose if he is revealed by a good B and is subsequently fired. This increases his incentive to hire a good B.

For T, offering severance pay has two effects: Expected profit increases in s through its effect on α_b. This effect is proportional to $r_M - r_B$, i.e. the loss to M if he is fired. On the other hand, s is a direct cost that must be paid with probability $(1 - \alpha_0)\alpha_b\phi q_{bg}$, i.e. the probability that M is bad, B is good, $z = d$ *and* $y = 1$. While the precise conditions are awkward to state, a variety of cases can occur:

(i) By offering $s = \delta(r_M - r_B)$, T can completely eliminate strategic recruiting. Then, α_b has the same value that it would have if $\phi = 0$, and does not depend on ϕ. Without a negative effect of ϕ on α_b, it follows from the analysis in Section 3.2 that the firm's profit is increasing in ϕ, i.e. open communication is optimal. It depends on $r_M - r_B$ and k_1 whether this severance pay is profitable for the firm. In particular, $r_M - r_B$ must be sufficiently small so that if $z = d$ and $y = 1$, T would actually want to fire M and promote B, instead of just retaining M in order to avoid paying s.

[10] An alternative but not more realistic setup is to assume that output cannot be verified, but that severance payments can be specified for the case that M is fired and B subsequently promoted (since without B's signal, T would never have an incentive to promote B). The results obtained under this assumption differ only slightly from those presented here.

(ii) If $r_M - r_B$ exceeds a critical value, then T does not offer any severance, as the direct expected costs always exceed the benefit of slightly increasing α_b. In this case, the results of Section 3.2 apply unchanged.

(iii) Between these two extreme cases lies an intermediate range of $r_M - r_B$ where T offers some severance that ameliorates strategic recruiting without eliminating it completely, and where it would allow more open communication.

4.2 Bonus payments

Instead of offering a severance payment, T can offer a bonus b for high output in order to increase M's incentive to recruit a good B. In our two-period model, a bonus paid whenever $y = 1$ is very similar to a raise of r_M in the second period, since M is also retained only if $y = 1$. (Such a raise could be seniority-based, i.e. be offered only to a retained M, even under the non-verifiability assumptions of Section 3.) The only difference between b and Δ_r is that if $z = d$ and $y = 1$, a bad M would receive the bonus but not the raise.

We are not concerned with the firm's optimal wage policy in this paper, but want to address the question: How useful are bonus payments in the presence of raises and severance payments as feasible instruments? Some insight is given by the following result.

Proposition 5 *Let $\pi(s, b, \Delta_r)$ denote the firm's expected profit as a function of a severance payment s, a bonus b and a raise Δ_r for a retained M. Then $\delta(d\pi/db) = d\pi/d\Delta_r + \delta(d\pi/ds)$.*

Thus, a bonus is equivalent to a severance payment combined with a raise of the same discounted magnitude.

4.3 Recruitment authority

One way to prevent M from recruiting strategically would be to simply assign recruitment decisions to other people. This idea raises two questions: Is this possible, and, does it solve the problem?

For a number of reasons, in many organizations, hiring decisions are not left to supervisors only. Higher-level superiors, peers, consultants, and the HR department may all be involved. To what extent restricting a supervisor's influence over hiring decisions is desirable, however, depends on the nature of the job. For the same reasons that an organization may have to rely on a supervisor's subjective evaluation of an employee's performance instead of objective measures, it may also have to rely on the supervisor's judgement about candidates is when hiring a new employee. Hence, in practice, "most line managers make the final employment or promotion decision" (South and Matejka 1990).

But even if restricting a manager's hiring decisions is feasible, there remain numerous ways in which a manager can abuse his authority in order to defend his position against a subordinate. He can (i) misrepresent the subordinate's performance by giving her bad evaluations or taking credit for her good ideas, (ii) sabotage the performance of the subordinate by e.g. withholding important information, or (iii) hinder the subordinate's development on the job. These abuses of authority are more subtle and not quite as effective as strategic recruiting decisions, but they are even more difficult to detect or prevent.

Our model is literally concerned with recruiting decisions, but can be easily reinterpreted to capture other forms of abuse of authority. Suppose, for example, that M has no recruiting authority over B. At the time of entry in the firm, B's productivity is low (or bad), but possibly improves over time by training and development. Now, if B's human capital acquisition is (apart from her own effort) a function of M's effort α in supporting B's development, then all our results of Section 3 follow.[11]

Therefore, as long as vertical competition persists, i.e. as long as a manager has to fear being replaced by a more productive subordinate, preventing strategic recruiting does not solve the problem, because managers can usually protect themselves in other ways. Thus, our theory addresses the abuse of authority in general.

[11] It is also quite realistic to assume that M's cost of effort is U-shaped as in (1): Actively supporting B is costly, but actively hindering B's development is also costly if there is some monitoring by T.

4.4 Career paths

The underlying problem, namely vertical competition, can be removed by an appropriate design of career paths.

(i) Employment guarantee: A crude but effective measure is to guarantee not to fire a manager regardless of bad news about him. Carmichael (1988) argues that tenure in academia protects senior faculty against being replaced by more productive assistant professors. This assures the incentive to recruit the most productive juniors. While lifetime employment may or may not be optimal in academia, employment guarantees are rarely offered in firms that have to survive in a competitive environment.[12]

Even in our simple model which does not involve any moral hazard in production, a guarantee to keep M employed in the second period is inferior to a chain of command, unless open communication is strongly desired for other reasons ($\omega >> 0$): In both cases strategic recruiting is successfully prevented. But, while with a chain of command, T can profitably hire a new M if output is zero, this is impossible with an employment guarantee. Moreover, with the implicit incentive contract according to Proposition 1, M has a *positive* incentive to recruit a good subordinate, whereas he is indifferent if his employment is guaranteed.

(ii) Non-replacement and seniority rules: Many organizations follow a policy of never promoting an employee to the position of her immediate superior. To some extent, this rule removes the threat of replacement for M: If B cannot hope to get M's position as a direct consequence of communicating with T, she will have much less incentive to do so. The protection for M might be only limited, though: If B credibly informs T that M is unproductive, M will be fired even if B does not get promoted; and even if B has no specific interest in harming M, she may communicate with T in order to make a good impression, hoping to get promoted to a different department sometime later.

More effective in preventing vertical competition, but also much more bureaucratic, is

[12] Well-known examples are partnerships in law, auditing and consulting firms. Similarly, lifetime employment has been a central element in the organization of large Japanese corporations. In both cases, however, there seems to be a current trend away from such employment guarantees.

to promote employees by seniority rather than performance. In fact, Doeringer and Piore (1971) argue that the bureaucratic features of internal labor markets are necessary to provide experienced workers with an incentive to train younger workers: "The effectiveness of on-the-job training depends heavily upon the willingness of experienced workmen to teach new workers. Incumbent employees are thus in a position to frustrate this training process..." (p.84). Hence, "A certain degree of wage rigidity and job security is therefore necessary for on-the-job training to operate at all" (p.33).

5 Concluding remarks

In this paper we have suggested an *incentive-based* explanation for the "chain of command". We have argued that disrupting skip-level communication can mitigate managers' incentives to abuse their authority over personnel, where otherwise the fear of being replaced may lead them to hire weaker but less dangerous subordinates. Trading off the benefits of open communication and the costs caused by strategic recruiting, the firm may find it optimal to restrict or even completely prohibit skip-level communication.

An important issue, although beyond the scope of formal treatment in this paper, is how a chain of command can be implemented in practice. In part, the openness of communication ϕ is determined by the cost of communicating which the firm can influence. For instance, if employees of different levels have offices on the same floor and open-door policies are applied, skip-level communication can more easily take place than in firms where office location reflects hierarchical rank, doors are generally shut, and higher-level supervisors are only accessible by appointment. Second, openness also depends on the ability of subordinates to provide top management with convincing evidence that they are more qualified than their respective superior. This depends on the nature of the job and organizational procedures.

In case the costs of communication are not sufficient to deter skip-level communication, the top manager may attempt to build up a reputation of not talking to lower-level employees, not listening to their complaints about their supervisors, or even punishing them for disloyal behavior. While building up such a reputation could be difficult for the individual manager, the firm as a whole can encourage such behavior by fostering an organizational culture based on the chain of command and the authority of supervisors.[13]

Moreover, in a hierarchy with more than three ranks, top managers may fear to become the next victim of the subordinate who was rewarded for being disloyal. They may hence have an individual reason to ignore or punish a subordinate if telling on her supervisor identifies her as a "troublemaker" or "traitor".[14]

Our analysis suggests that the design of an intra-firm communication structure must take into account its fit with the firm's human resource practices and the employees' possible strategic behavior. As we have shown, the wage structure, the effectiveness of recruiting good line managers (which also depends on resources spent), the monitoring of personnel decisions, and job design, all affect the firm's optimal level of openness of communication.

Clearly, our emphasis on the benefits of restricted communication goes against the tide of current management literature. In the past decade, many have argued that traditional organizational structures emphasizing the importance of a chain of command are obsolete and, in particular, that they fail to stimulate the employees' motivation and inhibit firms' flexibility. Consequently, looser organizational structures have been advocated: open-door policies, and the evaluation of supervisors by subordinates (as part of "360-degree" performance reviews) are becoming increasingly popular.

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[13] In line with this reasoning, the Bureau of National Affairs found in a survey of formal complaint procedures within firms that managers' decisions are almost always upheld by higher levels in response to complaints (Bureau of National Affairs 1979). An alternative explanation for this finding, however, would be that higher levels refrain from "undermining the authority" of supervisors because their trustworthiness is important for the subordinates' work morale, cf. Prendergast (1994).

[14] ...Thus, *"Princes in this case hate the traitor, though they love the treason"* (Samuel Daniel, *The Tragedie of Cleopatra*, 1611) A modern application of this principle is the case of "a CitiCorp manager named David Edwards [who] learned that the bank was engaging in a variety of illegal banking practices. [...] Edwards told his boss, who seemed uninterested and recommended that Edwards just forget it. [...] After eventually going all the way to the upper echelons of the organization, Edwards finally reported his findings to the Board of Directors. They took action against the illegal practices but also fired Edwards for being disruptive. What exactly did Edwards do to warrant termination? [...] one of his biggest 'mistakes' was going over his boss's head." (Barney and Griffin 1992)

In practice, however, middle managers often feel threatened by their superior's open-door policies that encourage their subordinates to communicate with top management behind their back. In response, some argue that open-door policies need to be planned very carefully (Shenhar 1993), whereas others favor a return to hierarchical communication structures (Falconi 1997). Similarly, 360-degree reviews are usually intended as a feedback tool only and a subordinate's evaluation of her superior is usually only made available to the latter, but not to higher levels.

In the light of our analysis, restricting intra-firm communication may not be so much due to the organization's concern for the well-being of middle managers. Rather, organizations appear to be aware of the effective means middle managers possess in order to protect themselves against potentially dangerous subordinates, and of the fact that hierarchical communication can prevent them from abusing their authority.

It follows from our analysis that it is unwise to allow or even encourage communication between lower and higher levels in the hierarchy without considering the consequences for middle managers *and their strategic responses.* More generally, in organizations that do not restrict communication, the flow of information *in equilibrium* may be limited if people anticipate that what they say to others might be used against them. Similarly, interpreting the spreading of bad news about one's superior as a form of "disloyal" behavior, our results suggest that organizations take considerable risks when tolerating or even encouraging disloyalty of employees to their superiors. But this is not because of its direct consequences, which may well be beneficial since disloyalty helps to detect and replace unproductive employees. Rather, the harm is caused in an indirect way through the counter-productive activities of supervisors who see their position threatened by disloyal subordinates.

A Proofs

Proof of Proposition 1:

Preliminaries: Notation and updating procedure

1. For a given belief $\mathbf{p} = (p_{gg}, p_{gb}, p_{bg}, p_{bb})$ about the composition of the (M,B)-team (cf. Section 2.2), denote by $p_M(\mathbf{p})$ and $p_B(\mathbf{p})$ the marginal probabilities that M and B are good, respectively. That is, $p_M(\mathbf{p}) = p_{gg} + p_{gb}$ and $p_B(\mathbf{p}) = p_{gg} + p_{bg}$.

2. In some situations the types of M and B can be seen as stochastically independent. Here, if e.g. Prob(M=g) $= a$ and Prob(B=g) $= b$, we will use the shorthand notation $[a, b] := (ab, a(1-b), (1-a)b, (1-a)(1-b))$ for a team belief. Then, the expected output $[a, b]\mathbf{q}$ is increasing in both a and b. Moreover, the assumption $q_{gb} \geq q_{bg}$, i.e. that M is relatively more important than B, implies that $[a, b]\mathbf{q} \geq [b, a]\mathbf{q}$ if and only if $a \geq b$.

3. Recall that a good M is hired with probability α_0. A good M hires a good B with probability α_g. A bad M hires a good B with probability α_b. Hence, the prior for T's belief about the team is $\mathbf{p_1} = (\alpha_0\alpha_g, \alpha_0(1-\alpha_g), (1-\alpha_0)\alpha_b, (1-\alpha_0)(1-\alpha_b))$.

4. Next, consider how the signals y and z affect T's beliefs, starting from any prior $\mathbf{p} = (p_{gg}, p_{gb}, p_{bg}, p_{bb})$. If B reveals that she is good and M is bad, T has perfect information about (M,B). Hence, T's updated belief about the team is $t^d(\mathbf{p}) = (0, 0, 1, 0)$. On the other hand, if $z = c$, then, her posterior is

$$t^c(\mathbf{p}) = \frac{1}{1 - \phi p_{bg}} \left(p_{gg}, p_{gb}, (1-\phi)p_{bg}, p_{bb}\right).$$

Depending on whether $y = 1$ or $y = 0$ is observed, the posterior of $\mathbf{p}$ is

$$\begin{aligned} t^1(\mathbf{p}) &= \frac{1}{\mathbf{pq}} \left(p_{gg}q_{gg},\ p_{gb}q_{gb},\ p_{bg}q_{bg},\ p_{bb}q_{bb}\right) \quad \text{or} \\ t^0(\mathbf{p}) &= \frac{1}{1-\mathbf{pq}} \left(p_{gg}(1-q_{gg}),\ p_{gb}(1-q_{gb}),\ p_{bg}(1-q_{bg}),\ p_{bb}(1-q_{bb})\right). \end{aligned}$$

5. For the proof below, we need to know how T's belief about B is affected by y and z. It straightforwad to show that for any team belief $\mathbf{p} = (p_{gg}, p_{gb}, p_{bg}, p_{bb})$, we have $p_B(t^c(\mathbf{p})) < p_B(\mathbf{p})$. Moreover, $p_B(t^0(\mathbf{p})) < p_B(\mathbf{p})$ as long as $p_{gg}p_{bb} > p_{gb}p_{bg}$: $p_B(\mathbf{p}) - p_B(t^0(\mathbf{p}))$ has the same sign as $(p_{gg} + p_{bg})(1 - \mathbf{pq}) - (1-q_{gg})p_{gg} - (1-q_{bg})p_{bg} = p_{gg}q_{gg} +$

$p_{bg}q_{bg} - (p_{gg} + p_{bg})\mathbf{pq}$, which is increasing in q_{gg} and decreasing in q_{bb}. Substituting q_{gb} for q_{gg} and q_{bg} for q_{bb} (the minimal and maximal values, respectively), and using $p_{bb} = 1 - p_{gg} - p_{gb} - p_{bg}$, this expression simplifies to $[p_{gg} - (p_{gg} + p_{bg})(p_{gg} + p_{gb})](q_{gb} - q_{bg})$. Add $p_{gg}p_{bb}$ to the expression in []-brackets, use again $\sum p_{ij} = 1$, and substract $p_{gg}p_{bb}$, to obtain $p_{gg}p_{bb} - p_{gb}p_{bg}$. Notice that the assumption $p_{gg}p_{bb} > p_{gb}p_{bg}$ is satisfied for the initial team belief $\mathbf{p_1}$.

6. Finally, we determine how T's beliefs are affected by her decision regarding M. If T promotes B and a new B is hired, her belief is $t^p(\mathbf{p}) = [p_B(\mathbf{p}), \alpha_n]$. If she hires a new M, this M is good with probability α_0. By assumption, B is retained if and only if she is good (the probability of which is $p_B(\mathbf{p})$). Otherwise, a new B is hired and is good with probability α_n. Thus, T's belief upon hiring an new M is

$$t^h(\mathbf{p}) = [\alpha_0, p_B(\mathbf{p}) + \alpha_n(1 - p_B(\mathbf{p}))] = [\alpha_0, p_{gg} + p_{bg} + \alpha_n(p_{gb} + p_{bb})]$$

If T retains M, her belief is

$$t^r(\mathbf{p}) = (p_{gg} + \alpha p_{gb}, (1-\alpha)p_{gb}, p_{bg} + \alpha p_{bb}, (1-\alpha)p_{bb}).$$

This transition function is obtained as follows: if the team (M,B) is (g,g) or (b,g), the team is not changed if M is retained, since M always retains a good B. On the other hand, if the team is (g,b) or (b,b), then a new B is hired, in which case the composition of the team remains unchanged with probability $(1-\alpha)$ and is "upgraded" (from (b,b) to (b,g) or from (g,b) to (g,g), respectively) with probability α.

T's best response: We first determine T's best response to M's strategy under the assumption that $\alpha_g \geq \alpha_b$.

1. If $z = d$, T knows that M is bad and B is good. If T promotes B, her new expected team is $t^p((0,0,1,0)) = [1, \alpha_n]$. If she hires a new M, her new expected team is $t^h((0,0,1,0)) = [\alpha_0, 1]$. If she retains M, her belief is $t^r(0,0,1,0) = (0,0,1,0) = [0,1]$. Since a team $[1, \alpha_n]$ is preferred to a team $[\alpha_n, 1]$ (cf. *Preliminaries* point 2), and because of $\alpha_n > \alpha_0$, it follows that to promote B is T's best action.

2. Suppose now that $z = c$ and $y = 0$. If T hires a new M, her team belief is $[\alpha_0, p_B + (1 - p_B)\alpha_n]$, where p_B is evaluated for the posterior $t^c(t^0(\mathbf{p_0}))$. If she promotes

B instead, her belief is $[p_B, \alpha_n]$. Since $p_B + (1-p_B)\alpha_n \geq \alpha_n$, T would rather hire a new M than promote B if $\alpha_0 \geq p_B$. This is indeed the case: Equation (2) states the assumption that $\alpha_0 \geq p_B(\mathbf{p_0})$. Moreover, both signals $y = 0$ and $z = c$ are bad news about B, i.e. $p_B(t^0(\mathbf{p_1})) < p_B(\mathbf{p_1})$ and $p_B(t^c(\mathbf{p})) < p_B(\mathbf{p})$ (see above). Together, these inequalities imply $\alpha_0 \geq p_B(t^c(t^0(\mathbf{p_0})))$.

It remains to compare hiring a new M with retaining M. Hiring is preferred to retaining if $t^h(t^c(t^0(\mathbf{p_0})))\mathbf{q} \geq t^r(t^c(t^0(\mathbf{p_0})))\mathbf{q}$. The difference $[t^h(.) - t^r(.)]\mathbf{q}$ equals

$$\begin{aligned} &\alpha_0(1-\alpha_0)\Big\{\alpha_b(1-\phi)(1-q_{bg})^2 - \alpha_g(1-q_{gg})(q_{gg}-q_{bg}) \\ &\quad + [q_{gb} - q_{bb} + \alpha_n c][q_{gb} - q_{bb} + \alpha_g(1-q_{gb}) - \alpha_b(1-q_{bb})]\} \\ &\quad / \{1 - \alpha_0[\alpha_g + (1-\alpha_g)q_{gb}] - (1-\alpha_0)[\alpha_b(q_{bg} + \phi(1-q_{bg})) + (1-\alpha_b)q_{bb}]\}, \end{aligned} \tag{6}$$

where $c := q_{gg} + q_{qbb} - q_{gb} - q_{bg} > 0$ because of complementarity. This expression is positive if $q_{gg} = 1$ (as the only negative term in the numerator then vanishes), implying that T hires a new M. This is the only part of the proof that relies on the assumption $q_{gg} = 1$. Without this assumption, the necessary and sufficient condition for the existence of the equilibrium derived here is that the numerator in (6) be positive.

3. Finally, suppose that $z = c$ and $y = 1$. Retaining M leads to the team belief $t^r(t^c(t^1(\mathbf{p_0})))$. Retaining is preferred to hiring a new M if $t^r(t^c(t^1(\mathbf{p_0})))\mathbf{q} \geq t^h(t^c(t^1(\mathbf{p_0})))\mathbf{q}$. The difference $[t^r(.) - t^h(.)]\mathbf{q}$ equals

$$\begin{aligned} &\alpha_0(1-\alpha_0)\Big\{(q_{gb}-q_{bb})^2 + \alpha_b q_{bg}(q_{gg}-q_{bg})\phi + (\alpha_g - \alpha_b)\left[(q_{gg} - \alpha_n q_{gb})c + (q_{gg}-q_{gb})(q_{gb}-q_{bb})\right] \\ &\qquad + c\left[\alpha_n(1-\alpha_b)(q_{gb}-q_{bb}) + \alpha_b(q_{gg}+q_{gb}-q_{bg}-q_{bb})\right]\} \\ &\qquad / \{(1-\alpha_0)(1-\alpha_b)q_{bb} + \alpha_b(1-\alpha_0)(1-\phi)q_{bg} + \alpha_0[q_{gb} + \alpha_g(q_{gg}-q_{gb})]\}, \end{aligned} \tag{7}$$

which is positive.

Moreover, the assumption $\alpha_0 \geq \alpha_0\alpha_g + (1-\alpha_0)\alpha_b \Leftrightarrow \alpha_0(1-\alpha_g) \geq (1-\alpha_0)\alpha_b$ ensures that $t^r(t^c(t^1(\mathbf{p_0})))\mathbf{q} \geq t^p(t^c(t^1(\mathbf{p_0})))\mathbf{q}$, i.e. that $[t^r(.) - t^p(.)]\mathbf{q} =$

$$\begin{aligned} &\{[(1-\alpha_g)\alpha_0 q_{gb} - (1-\alpha_0)(1-\phi)\alpha_b q_{bg}][q_{gb} - q_{bg} + \alpha_n(q_{gg}-q_{gb})] \\ &\quad + \alpha_0(1-\alpha_n)[(1-\alpha_g)q_{gb}(q_{bg}-q_{bb}) + \alpha_g q_{gg}(q_{gg}-q_{gb})]\} \\ &\quad / \{(1-\alpha_0)(1-\alpha_b)q_{bb} + \alpha_b(1-\alpha_0)(1-\phi)q_{bg} + \alpha_0(q_{gb} + \alpha_g(q_{gg}-q_{gb}))\} \end{aligned}$$

is positive. Thus, T's best action is to retain M.

M's best response: Given T's strategy, the probability of retention is $P_{ret}(\alpha) = \alpha q_{gg} + (1-\alpha)q_{gb}$ for a good M and $P_{ret}(\alpha) = \alpha(1-\phi)q_{bg}+(1-\alpha)q_{bb}$ for a bad M. After substituting these expressions into (3), maximization with respect to α leads to the expressions for α_g and α_b stated in the proposition.

Uniqueness: Since T's best response was derived for any $\alpha_g \geq \alpha_b$, the equilibrium derived is unique unless there exists an equilibrium in which $\alpha_g < \alpha_b$. This would require that T provides negative incentives, i.e. that she retains M if $y = 0$ and $z = c$, and fires him if $y = 1$. For such an equilibrium to exist in turn requires that for some ϕ, both (6) and (7) be negative. We show that this can never be the case. To see this, notice that the numerator in (6) is decreasing in ϕ, while the numerator of (7) is increasing in ϕ. Specifically, (6) can be negative only if ϕ exceeds

$$\frac{(q_{gb} - q_{bb} + \alpha_n c)[q_{gb} - q_{bb} + \alpha_g(1 - q_{gb}) - \alpha_b(1 - q_{bb})] + (q_{gg} - q_{bg})[\alpha_b(1 - q_{bg}) - \alpha_g(1 - q_{gg})]}{(\alpha_b(1 - q_{bg})(q_{gg} - q_{bg})}.$$

However, substituting this value for ϕ in (7) yields

$$\frac{(q_{gb} - q_{bb} + \alpha_n c)[q_{gb} - \alpha_b q_{bg} - (1 - \alpha_b)q_{bb}] + \alpha_g[(q_{gg} - q_{gb})(q_{gg} - q_{bg}) + (1 - \alpha_n)(q_{gb} - q_{bg})c]}{1 - q_{bg}},$$

which is positive, so that (7) is also positive for any larger ϕ. ■

Proof of Proposition 2: In equilibrium, the firm's *ex ante* expected composition of the (M,B)-team after the first period is

$$E(\mathbf{p_2}) = \phi(1 - \alpha_0)\alpha_b t^p(t^d(\mathbf{p_1}))$$

$$+[1 - \phi(1 - \alpha_0)\alpha_b][(t^c(\mathbf{p_1})\mathbf{q})t^r(t^1(t^c(\mathbf{p_1}))) + (1 - t^c(\mathbf{p_1})\mathbf{q})t^h(t^0(t^c(\mathbf{p_1})))].$$

The first term is the probability that B is promoted, multiplied by the associated expected team belief. The second term covers the case $z = c$, where M is retained with (conditional) probability $t^c(\mathbf{p_1})\mathbf{q}$ and fired with probability $1-t^c(\mathbf{p_1})\mathbf{q}$. Plugging $\mathbf{p_2}$ into (4), the firm's expected profit can be expressed in the form $\pi = A + B\alpha_b(\phi) + C\phi\alpha_b(\phi) + D\phi$, where

$$A \quad = \quad \alpha_0\alpha_g q_{gg} + \alpha_0(1 - \alpha_g)q_{gb} + (1 - \alpha_0)q_{bb} - (1 + \delta)(r_M + r_B)$$

$$
\begin{aligned}
& +\delta \Big\{ \alpha_0(1-\alpha_0)(1-\alpha_n)\Big[(1-\alpha_g)(q_{gb}-q_{bb})q_{gb}+q_{bb}^2+q_{gb}(1-q_{bb})+\alpha_g(q_{bg}-q_{bb})\Big] \\
& +\alpha_0\alpha_n q_{gg}+\alpha_0^2(1-\alpha_n)[\alpha_g q_{gg}+(1-\alpha_g)q_{gb}]+(1-\alpha_0)[\alpha_n q_{bg}+(1-\alpha_n)q_{bb}] \\
& +\alpha_0(1-\alpha_0)(q_{gg}-q_{bg})[\alpha_g(q_{gg}-\alpha_n q_{gb})+\alpha_n(q_{gb}-q_{bb})]\} > 0 \\
B \;=\; & (1-\alpha_0)\{(q_{bg}-q_{bb})+\delta(1-\alpha_n)[\alpha_0 c+q_{bg}-q_{bb}+\alpha_0 q_{bb}(q_{gb}-q_{bb})] \\
& -\delta(q_{bg}-\alpha_n q_{bb})\alpha_0(q_{gg}-q_{bg})\} <> 0, \\
C \;=\; & (1-\alpha_0)\delta[(1-\alpha_n)(q_{gb}-q_{bg})+(\alpha_n-(1-q_{bg})\alpha_0)(q_{gg}-q_{bg})] > 0, \quad \text{and} \\
D \;=\; & (1+\delta)\omega > 0, \qquad (8)
\end{aligned}
$$

and A through D are independent of ϕ and α_b. Differentiate $\pi(\phi, \alpha_b(\phi))$ twice with respect to ϕ to obtain $d^2\pi/d\phi^2 = 2C\partial\alpha_b/\partial\phi$, where C is positive, and according to Proposition 1, α_b is decreasing in ϕ. Hence, π is concave in ϕ. ■

Proof of Proposition 3: If $k_1 = 0$, then from Proposition 1 it follows that for any $\phi \geq 1 - q_{bb}/q_{bg}$, α_b equals zero. Thus, expressing π and α_b as functions of ϕ, we have $\pi(0) - \pi(\phi) = B[\alpha_b(0) - \alpha_b(\phi)] - C\alpha_b(\phi) = B\alpha_b(0)$, using the notation of (8). The middle term in the {}-brackets in B is positive, and if δ □ 1, the first term exceeds the third, so that B is positive. ■

Proof of Proposition 4: Assuming that the optimal ϕ^* is interior, this ϕ is given by the first-order condition

$$
\frac{d\pi}{d\phi} = C\alpha_b(\phi) + D + (B + C\phi)\frac{\partial\alpha_b(\phi)}{\partial\phi} = 0, \qquad (9)
$$

in the notation of (8). Since π is concave in ϕ, it follows that $d\phi^*/dx$, the response of the optimal ϕ to a change in any parameter x of the model, has the same sign as $d^2\pi/(d\phi dx)$, which is obtained by differentiating (9) with respect to x.

For parts (a) through (c) of the proposition, notice that in (9), the parameters r_M, k_0 and k_1 affect only α_b but not B, C or D. Differentiating (9) and substituting for $(B + C\phi)$ from (9), we obtain

$$
\frac{d^2\pi}{d\phi dx} = C\frac{\partial\alpha_b}{\partial x} + (B + C\phi)\frac{\partial^2\alpha_b}{\partial\phi\partial x} = C\left(\frac{\partial\alpha_b}{\partial x} - \frac{\alpha_b}{\partial\alpha_b/\partial x}\,\frac{\partial^2\alpha_b}{\partial\phi\partial x}\right) - \frac{D}{\partial\alpha_b/\partial x}\,\frac{\partial^2\alpha_b}{\partial\phi\partial x}. \qquad (10)
$$

Evaluating (10) for r_M, k_0 and k_1 in place of x, we get

$$\frac{d^2\pi}{d\phi dr_M} = -\frac{1}{r_M - r_B}\left(\frac{k_1}{k_0+k_1}C + D\right) < 0, \qquad \frac{d^2\pi}{d\phi dk_0} = \frac{D}{k_0+k_1} \geq 0$$

$$\text{and} \quad \frac{d^2\pi}{d\phi dk_1} = \frac{C+D}{k_0+k_1} > 0,$$

since C is positive and D is nonnegative.

Part (d): A change in α_0 affects B and C in (9) but not α_b. Therefore, we have

$$\frac{d^2\pi}{d\phi d\alpha_0} = \frac{\partial C}{\partial \alpha_0}\alpha_b + \left(\frac{\partial B}{\partial \alpha_0} + \frac{\partial C}{\partial \alpha_0}\phi\right)\frac{\partial \alpha_b}{\partial \phi} = \frac{1}{C}\left[\left(C\frac{\partial B}{\partial \alpha_0} - B\frac{\partial C}{\partial \alpha_0}\right)\frac{\partial \alpha_b}{\partial \phi} - \frac{\partial C}{\partial \alpha_0}D\right],$$

after substituting for α_b from (9). Here, the sign of the term in ()-parentheses on the right-hand side is indeterminate, whereas $\partial C/\partial \alpha_0$ is negative, since both factors of C are decreasing in α_0. Thus, ϕ^* is increasing in α_0 if $D = (1+\delta)\omega$ is sufficiently large. – Part (e) is obvious, as from (8), $d^2\pi/(d\phi d\omega) = 1 + \delta$. ■

Proof of Proposition 5: With a bonus b paid to M whenever $y = 1$, a raise Δ_r for M in the second period if M is retained, and a severance payment s that is paid whenever M is fired even though $y = 1$ (which can happen only if M is bad), straightforward generalization of M's payoff function (3) leads to the recruiting efforts

$$\alpha_g = \frac{1}{2(k_0+k_1)}[2k_1 + (q_{gg} - q_{gb})b + \delta(q_{gg} - q_{gb})(r_M - r_M + \Delta_r)] \qquad \text{and}$$

$$\alpha_b = \frac{1}{2(k_0+k_1)}[2k_1 + (q_{bg} - q_{bb})b + \delta((1-\phi)q_{bg} - q_{bb})(r_M - r_M + \Delta_r) + \phi q_{bg}s].$$

Moreover, the firm's profit function contains the terms

$$-\mathbf{p_1 q}b \; - \; \phi(1-\alpha_0)\alpha_b q_{bg}s - \delta(1 - \phi(1-\alpha_0)\alpha_b)(t^c(\mathbf{p_1})\mathbf{q})\Delta_r$$

in addition to (8). Then, because

$$\delta\frac{\partial \alpha_g}{\partial b} = \frac{\partial \alpha_g}{\partial \Delta_r}, \qquad \delta\frac{\partial \alpha_b}{\partial b} = \frac{\partial \alpha_b}{\partial \Delta_r} + \delta\frac{\partial \alpha_b}{\partial s}, \quad \text{and} \quad \delta\frac{\partial \pi}{\partial b} = \frac{\partial \pi}{\partial \Delta_r} + \delta\frac{\partial \pi}{\partial s},$$

it follows that

$$\delta\left(\frac{\partial \pi}{\partial b} + \frac{\partial \pi}{\partial \alpha_b}\frac{\partial \alpha_b}{\partial b} + \frac{\partial \pi}{\partial \alpha_g}\frac{\partial \alpha_g}{\partial b}\right) = \frac{\partial \pi}{\partial \Delta_r} + \frac{\partial \pi}{\partial \alpha_b}\frac{\partial \alpha_b}{\partial \Delta_r} + \frac{\partial \pi}{\partial \alpha_g}\frac{\partial \alpha_g}{\partial \Delta_r} + \delta\left(\frac{\partial \pi}{\partial s} + \frac{\partial \pi}{\partial \alpha_b}\frac{\partial \alpha_b}{\partial s} + \frac{\partial \pi}{\partial \alpha_g}\frac{\partial \alpha_g}{\partial s}\right),$$

which is the statement of the proposition. ■

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