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Incentives and Selection in Promotion Contests: Is It Possible to Kill Two Birds with One Stone?

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This paper investigates whether a designer can improve both the incentive provision and the selection performance of a promotion contest by making the competition more (or less) dynamic. A comparison of static (one-stage) and dynamic (two-stage) contests reveals that this is not the case. A structural change that improves the performance in one dimension leads to a deterioration in the other dimension. This suggests that modifications of the contest structure are an alternative to strategic handicaps. A key advantage of structural handicaps over participant-specific ones is that the implementation of the former does not require prior identification of worker types. Copyright © 2014 John Wiley & Sons, Ltd.

1. INTRODUCTION

Most employment relationships are characterized by competition among employees for promotion to a better paid, more attractive position. While such promotion contests are often just a by-product of a given hierarchical structure, they are sometimes actively used as an instrument in the practice of human resource management in professional occupations. For example, 'up-or-out' promotion policies are the norm in law or consulting firms, where vacant manager or partner positions are almost exclusively filled with insiders. Contests are also used to fill top management positions. A prominent example is Jack Welch, the former CEO of General Electric (GE), who designed the competition for his succession about 6 years before he actually left. Several candidates from inside GE knew that they were competing against each other for this job and that they would either become the next CEO or would have to leave the firm.[1] 'Up-or-out' promotion policies are also common in the competition between scientists: in each year, only the (relatively) best performing PhDs become assistant professors, and only the best among the assistant professors receive a tenured position, while less successful staff members have to leave.

In all these applications, promotion contests are used as a means to achieve two goals. First, the contest provides employees with incentives, because the prospect of moving up the ladder to higher levels within the same institution is a strong motivator for employees to exert effort in their current job.[2] Second, the contest helps to select the most able and productive candidate(s) for promotion.[3] The fact that both incentive provision and selection performance matter for corporations raises the question how these two goals are related to each other. Can contests be used as a device to maximize the incentives for effort provision while at the same time minimizing the probability that the 'wrong' contestant

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wins? Or, in other words, can promotion contests be designed in such a way that they kill two birds with one stone?

This paper investigates how modifications of the contest structure affect the performance in these two dimensions. In particular, we analyze whether a designer can improve both the incentive provision and the selection performance of a promotion contest by making the competition more (or less) dynamic. A comparison of incentive provision and selection performance in a *static* (one-shot) promotion contest and a *dynamic* (two-stage) promotion contest suggests that the two goals are incompatible. While the dynamic format performs better in terms of aggregate equilibrium efforts, the static contest dominates with respect to selection. An additional hierarchy level in promotion contests is therefore beneficial for incentive provision but detrimental for the accuracy in selection.

More generally, our results show that the trade-off between incentive provision and accuracy of selection established in previous work cannot be solved by structural variations: modifications that improve the performance in one dimension deteriorate the performance in the other dimension. Thus, the variations in the contest structure considered in this paper have similar effects as strategic handicaps.[4] Intuitively, contest structures that amplify the degree of heterogeneity between strong and weak workers perform well in terms of selection, as heterogeneity discourages weak workers relatively more than it induces strong workers to slack off. Pooling of workers in a simultaneous interaction tends to increase the effective degree of heterogeneity, implying that the one-stage contest delivers the best selection performance. In contrast, the more the structure of the competition moderates heterogeneity between workers, the better is its performance in the incentive dimension, because heterogeneity decreases the incentives for effort provision for both strong and weak workers in absolute terms. The separation of employees into pairwise interactions, for example, reduces the effective degree of heterogeneity, which then enhances incentives for effort provision.

From a practitioner's perspective, our results have two important implications: First, structural variations cannot ensure that a promotion contest serves both goals equally well. This suggests that a promotion contest should either be used to maximize incentives for effort provision in a preselected sample of similarly talented employees, or for the sorting of types if the talent of employees is not observable and alternative incentive schemes are available. Second, the finding that structural variations work similar to strategic handicaps is useful when the ability of contestants is unobservable and the designer cares about one of the two objectives only. While participant-specific handicapping schemes require information about the ability of each contestant, or at least some (possibly imperfect) signal of participants' ability, such information is not necessary to employ structural handicaps.

The remainder of this paper is structured as follows. We first discuss the related literature in Section 2. Section 3 introduces the formal model. Section 4 compares the equilibrium measures for incentive provision and selection performance of different contest formats. Section 5 discusses the intuition for and the limitations of our results, and Section 6 concludes the paper.

2. RELATED LITERATURE

Our paper contributes to three strands of the literature on contests. It is most closely related to previous work on the relation between incentives and selection in promotion contests. Baker *et al*. (1988) were the first to investigate whether promotion contests ensure that employees end up in those jobs for which they are best suited, assuming that skill requirements differ qualitatively across hierarchy levels.[5] Our approach is different from theirs in that we consider situations where talent requirements are qualitatively similar across hierarchy levels but where the ability to perform the tasks differs across workers. In other words, while the heterogeneity in Baker *et al*. is 'horizontal', the heterogeneity considered here is 'vertical'. Obvious examples for settings where vertical heterogeneity matters are law and consultancy firms. Similarly, top managers and CEOs perform very similar tasks, and both assistant and tenured professors teach and conduct research. Regarding the assumption that the ability to perform the same task differs across workers, our paper is closely related to work by Tsoulouhas *et al*. (2007), who study a one-stage promotion contest where insiders and outsiders compete for a CEO position. Assuming that both the quality of the promoted agent and the provision of incentives matter for the designer, they find that the two goals are conflicting if the ability of outsiders is higher than the ability of insiders. While this result has a similar flavor as the one established in our paper, the focus of their study is on optimal handicapping in a setting where selection involves both insiders and outsiders, but only effort provision by insiders is beneficial for the organization. In contrast, we consider how structural variations of

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within-firm competition affect incentive provision and selection performance. Our results show that the trade-off between these two goals established by Tsoulouhas *et al*. (2007) for the competition between insiders and outsiders is also present in purely internal promotion contests if a company employs workers of different types. In particular, we find that changes in the contest structure that make the within-firm competition more (or less) dynamic through additional (or less) hierarchy levels cannot improve the performance in both dimensions simultaneously.

The present paper contributes to the literature on optimal handicapping.[6] While it is well known that strategic handicaps in a static interaction between two heterogeneous agents may either improve incentives or selection, depending on whether the designer handicaps the 'favorite' or the 'underdog', a designer with a given goal might find this insight of limited help-participant-specific handicapping requires prior identification of workers' productivities, which is often infeasible in reality. The structural variations studied in the present paper have similar effects as strategic handicaps, but the important advantage that knowledge of individual productivities is not necessary. In that regard, the results of our paper are more closely related to recent work by Ridlon and Shin (2013). They analyze optimal handicapping strategies in repeated contests among heterogeneous workers under the assumption that the designer has imperfect information about the ability of her employees. Both the contest setting under investigation and the intuition for the results obtained are different from those in the present paper. Ridlon and Shin consider a repeated pairwise interaction and allow the principal to handicap conditional on the outcome of the first-round contest. Thus, the strategic effect of a handicap is complicated by the fact that workers adjust their effort choice in the first round to the expected handicapping policy in the second-round contest.

Finally, this paper is also related to recent contributions on optimal contest design. Ryvkin and Ortmann (2008) address the selection performance of different contest structures, but in contrast to our paper, they discard the effect of this variation on incentives.[7] Groh *et al*. (2012) consider both objectives, but they focus on different seedings in a dynamic contest, while we investigate how dynamic contests relate to static ones when participants are heterogeneous. The only existing comparison of static and dynamic contests with heterogeneous participants by Stracke (2013) restricts attention to incentives and discards the selection performance.

3. THE MODEL

3.1. A Promotion Contest with Heterogeneous Workers

Consider an entity that uses a promotion contest to fill a vacant high-level position that is of value P to workers from lower ranks.[8] Four risk neutral workers compete for the open position on the internal labor market. While working on their actual position, they are evaluated relative to their competitors, and the worker with the best performance is promoted at the end of the evaluation period. Workers know that they are being evaluated, and they are perfectly informed about their own productivity and the productivity of their colleagues.[9] To keep the theoretical analysis tractable, we assume that workers are of two different types: two workers are highly productive ('strong'), and two workers are less productive ('weak'). Each worker provides effort to increase his chances for a promotion. The organizing entity of the contest, the 'principal', cannot directly observe individual efforts but receives only a noisy ordinal performance signal. As a consequence, the promotion probability of a given worker is increasing in the worker's own effort and decreasing in the effort(s) provided by the worker's immediate opponent(s). Because the signal is noisy, however, the worker with the highest effort does not win with certainty. Specifically, it is assumed that the promotion probability p_i for worker i in a contest interaction is given by the ratio of own effort x_i over the effort(s) provided by all workers who participate in the respective competition.[10] Denoting the effort(s) provided by the immediate competitor(s) of worker i by $X_{-i} = \sum_{m \neq i} x_m$, where $m \in N$ and N is the set of competitors, the promotion probability reads

$$p_i(x_i, X_{-i}) = \begin{cases} \dfrac{x_i}{x_i + X_{-i}} & \text{if} \quad x_i, X_{-i} > 0 \\ \dfrac{1}{\#N} & \text{if} \quad x_i, X_{-i} = 0 \end{cases}, \tag{1}$$

where $\#N$ is the number of workers participating in the contest interaction.

While we do not explicitly model the payoff function of the principal, we assume that it has two arguments. First, the payoff of the principal is increasing in effort provision by employees; that is, higher work effort by employees translates into higher profits for the principal and vice versa. Second, it is important for the profitability of the firm that productive rather than unproductive workers are promoted, as 'up-or-out' promotion policies imply that losers of the promotion

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competition are lost for the organization.[11] Thus, the payoff of the principal is increasing in the accuracy in selection of the promotion contest. In sum, we assume that the principal pursues the following two objectives:

(1) maximization of aggregate effort by all workers (incentive provision)
(2) maximization of the probability that a strong worker wins (selection).

Arguably, the provision of incentives is an important goal for any corporation, and the prospect of being promoted to a better paid, more attractive position can be used to motivate and incentivize workers. At the same time, it is the inherent logic of promotion to promote productive and fire unproductive workers, in particular if 'up-or-out' promotion policies are used. One of the goals of our analysis is to find out whether a designer can improve both the incentive provision and the selection performance of a promotion contest by making the competition more (or less) dynamic. For this purpose, we compare the incentive and selection properties of a static (one-stage) contest with those of a dynamic (two-stage) pairwise elimination contest. The two different formats are depicted in Figure 1, which also shows that two different seedings are possible in the dynamic specification: either a strong worker competes against another strong worker (and a weak worker against another weak worker) in the parallel stage-1 interactions (denoted setting `SSWW`) or both stage-1 interactions are mixed in terms of the productivity of the competing workers (setting `SWSW`). In the comparison of the static and the dynamic contest formats, we assume that workers' productivities are not observable by the principal. Therefore, the seeding in stage 1 of the dynamic format is random: setting `SSWW` occurs with probability 1/3, while the probability that setting `SWSW` realizes is 2/3.[12]

3.2. Equilibrium Behavior by Workers in the One-stage Contest

The one-stage contest, denoted `I` in the following, is a special case of the model developed by (and extensively discussed in) Stein (2002). Specifically, we consider a setting with only two worker types and assume that the effort costs of strong workers, c_S, are lower than the effort costs of weak workers, c_W ($c_S \leq c_W$).[13] Because the one-stage contest is a simultaneous move game, the natural solution concept is Nash equilibrium. In an equilibrium, worker i with marginal effort costs c_i chooses his/her effort $x_i \geq 0$ so as to maximize the expected payoff $\Pi_i(\mathrm{I})$, taking the total effort of all other workers, X_{-i}, as given. Formally, the optimization problem of worker i reads as follows:

$$\max_{x_i \geq 0} \Pi_i(x_i, X_{-i}) = \frac{x_i}{x_i + X_{-i}} P - c_i\, x_i.$$

The first-order conditions, together with symmetry, yield individual equilibrium efforts

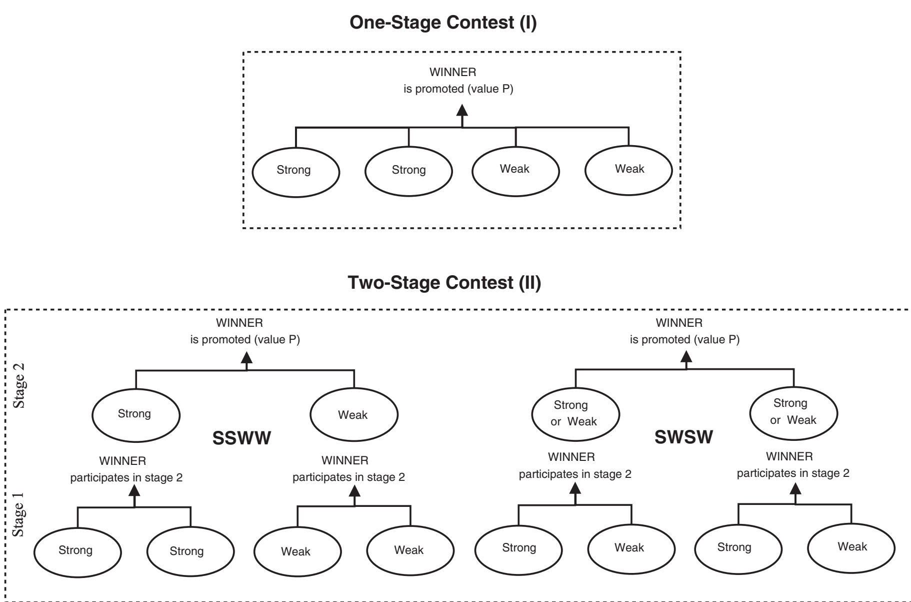

Figure 1. Design options available to the contest designer.

$$x_S^*(\mathrm{I}) = \begin{cases} \dfrac{3(2c_W - c_S)}{4(c_S + c_W)^2}P & \text{if } \dfrac{c_W}{c_S} < 2 \\ \dfrac{1}{4c_S}P & \text{if } \dfrac{c_W}{c_S} \geq 2 \end{cases} \quad (2)$$

$$x_W^*(\mathrm{I}) = \begin{cases} \dfrac{3(2c_S - c_W)}{4(c_S + c_W)^2}P & \text{if } \dfrac{c_W}{c_S} < 2 \\ 0 & \text{if } \dfrac{c_W}{c_S} \geq 2 \end{cases}$$

for strong and weak workers, respectively.[14] Equilibrium efforts determine both the incentive and the selection properties of the promotion contest. Our measure for the incentive provision performance of the one-stage contest, denoted $\mathcal{S}(\mathrm{I})$, is the sum of individual equilibrium efforts. Because two workers are strong and two are weak, we obtain

$$\mathcal{E}(\mathrm{I}) = 2x_S^* + 2x_W^*. \quad (3)$$

While the incentive provision measure depends on the absolute value of equilibrium efforts, winning probabilities depend on the ratio of equilibrium efforts. The selection performance, $\mathcal{S}(\mathrm{I})$, is defined as the probability that a strong worker wins the contest. The equilibrium winning probability of a strong worker must be multiplied by two, because two strong workers participate in the promotion contest, which gives

$$\mathcal{S}(\mathrm{I}) = \frac{x_S^*}{x_S^* + x_W^*}. \quad (4)$$

3.3. Equilibrium Behavior by Workers in the Two-stage Contest

The relevant solution concept for the two-stage contest is subgame perfect Nash equilibrium. The equilibrium is derived by backward induction. First, all possible stage-2 interactions must be solved. With four workers of two types, there are three potential stage-2 games, namely, `SS` (both workers are strong), `WW` (both workers are weak), and `SW` (one strong and one weak workers). As before, we assume that the effort costs of strong workers, c_S, are lower than the effort costs of weak workers, c_W ($c_S \leq c_W$). The formal optimization problem of worker i with effort cost c_i who competes against worker $j \neq i$ in stage 2 reads

$$\max_{x_{i2} \geq 0} \Pi_{i2}(x_{i2}, x_{j2}) = \frac{x_{i2}}{x_{i2} + x_{j2}} P - c_i x_{i2},$$

where x_{i2} and x_{j2} are individual efforts by workers i and j, respectively. A detailed solution of all stage-2 games is provided in Appendix B1 (Supporting information). The analysis reveals that the equilibrium effort of each worker depends on the worker's own productivity and on the productivity of the worker's opponent.[15] The formal expressions of stage-2 equilibrium efforts are displayed in Table 1. In that table, $x_{S2}^*(\mathrm{SS})$ denotes stage-2 equilibrium effort of a strong worker in the homogeneous interaction `SS`; $x_{W2}^*(\mathrm{WW})$ denotes stage-2 equilibrium effort of a weak worker in the homogeneous interaction `WW`; $x_{S2}^*(\mathrm{SW})$ and $x_{W2}^*(\mathrm{SW})$ are the equilibrium efforts of strong and weak workers, respectively, in the heterogeneous stage-2 interaction `SW`. Because stage-2 equilibrium efforts solve the last stage of the game, we can now move forward to stage 1.

3.3.1 Setting SSWW

The stage-1 interactions in setting `SSWW` ensure that one strong and one weak workers reach stage 2 with certainty.[16] Consequently, `SW` is the only possible constellation on stage 2. Thus, each strong worker knows that, conditional on reaching stage 2, the opponent will be a weak worker, while each weak worker anticipates that the interaction on stage 2, if reached, will involve a strong competitor. The only reward for winning stage 1 is the participation in stage 2, in which workers may then receive the promotion of value P. Thus, the expected equilibrium payoffs of a stage-2 interaction `SW` for strong and weak workers, $\Pi_{S2}^*(\mathrm{SW}) \equiv \Pi_{i2}(x_{S2}^*(\mathrm{SW}), x_{W2}^*(\mathrm{SW}))$ and $\Pi_{W2}^*(\mathrm{SW}) \equiv \Pi_{i2}(x_{W2}^*(\mathrm{SW}), x_{S2}^*(\mathrm{SW}))$, respectively, determine the continuation values for which workers compete in stage 1. This becomes clear when considering the optimization problem of some strong worker i, who competes with the second strong worker j:

$$\max_{x_{i1} \geq 0} \Pi_i(\mathtt{SSWW}) = \frac{x_{i1}}{x_{i1} + x_{j1}} \Pi_{S2}^*(\mathtt{SW}) - c_S x_{i1}.$$

Table 1. Stage-2 Equilibrium Efforts of Different Agents

homogeneous interaction		heterogeneous interaction	
Strong (`S`)	Weak (`W`)	Strong (`S`)	Weak (`W`)
$x_{S2}^*(\mathrm{SS}) = \frac{P}{4c_S}$	$x_{W2}^*(\mathrm{WW}) = \frac{P}{4c_W}$	$x_{S2}^*(\mathrm{SW}) = \frac{c_W}{(c_S+c_W)^2}P$	$x_{W2}^*(\mathrm{SW}) = \frac{c_S}{(c_S+c_W)^2}P$

The probability that worker i participates in stage 2, where participation is worth $\Pi^*_{S2}(\mathtt{SW})$ in equilibrium, is increasing in his/her stage-1 effort x_{i1}. Similarly, the two weak workers compete for participation in stage 2, which is worth $\Pi^*_{W2}(\mathtt{SW})$ for them. Let $x^*_{S1}(\mathtt{SSWW})$ and $x^*_{W1}(\mathtt{SSWW})$ denote the stage-1 equilibrium efforts in setting SSWW by strong and weak workers. They are given by

$$x^*_{S1}(\mathtt{SSWW}) = \frac{c_W^2}{4c_S(c_S+c_W)^2}P \quad \text{and}$$
$$x^*_{W1}(\mathtt{SSWW}) = \frac{c_S^2}{4c_W(c_S+c_W)^2}P,$$

respectively.[17] Then, the incentive measure for setting SSWW of the two-stage contest format, denoted $\mathcal{E}(\mathtt{SSWW})$, is the sum of individual equilibrium efforts over all participants and both stages. Summing up the equilibrium efforts of the two strong and the two weak workers in stage 1 and the equilibrium efforts of one strong and one weak worker in stage 2, we obtain

$$\mathcal{E}(\mathtt{SSWW}) = \underbrace{2\left[x^*_{S1}(\mathtt{SSWW}) + x^*_{W1}(\mathtt{SSWW})\right]}_{\text{stage 1 effort}} + \underbrace{x^*_{S2}(\mathtt{SW}) + x^*_{W2}(\mathtt{SW})}_{\text{stage 2 effort}}. \tag{5}$$

The selection measure, that is, the probability that a strong worker wins the contest, is determined by relative effort provision of stage-2 participants. As mentioned previously, one strong and one weak workers compete in stage 2, independently of stage-1 outcomes. Therefore, the selection measure $\mathcal{S}(\mathtt{SSWW})$ depends on the ratio of stage-2 equilibrium efforts $x^*_{S2}(\mathtt{SW})$ and $x^*_{W2}(\mathtt{SW})$:

$$\mathcal{S}(\mathtt{SSWW}) = \frac{x^*_{S2}(\mathtt{SW})}{x^*_{S2}(\mathtt{SW}) + x^*_{W2}(\mathtt{SW})}. \tag{6}$$

3.3.2 *Setting* SWSW

Because both stage-1 interactions are mixed in setting SWSW, the composition of the stage-2 competition is uncertain; any one of the three stage-2 games SS, WW, and SW is possible, as shown in Figure 1. Consequently, the solution of this setting is complicated by the fact that stage-1 continuation values are determined endogenously. To illustrate this complication, assume that a strong worker i and an arbitrary weak worker j compete in stage 1 for the right to participate in stage 2. Simultaneously, strong worker k and weak worker l compete for the remaining stage-2 slot in the other stage-1 interaction. Then, the optimization problems of workers i and j read

$$\max_{x_{i1}\geq 0} \Pi_i(\mathtt{SWSW}) = \frac{x_{i1}}{x_{i1}+x_{j1}} \underbrace{\left[\frac{x_{k1}}{x_{k1}+x_{l1}}\pi^*_{S2}(\mathtt{SS}) + \frac{x_{l1}}{x_{k1}+x_{l1}}\pi^*_{S2}(\mathtt{SW})\right]}_{\equiv P_i(x_{k1},x_{l1})} - c_S x_{i1}$$

$$\max_{x_{j1}\geq 0} \Pi_j(\mathtt{SWSW}) = \frac{x_{j1}}{x_{i1}+x_{j1}} \underbrace{\left[\frac{x_{k1}}{x_{k1}+x_{l1}}\pi^*_{W2}(\mathtt{SW}) + \frac{x_{l1}}{x_{k1}+x_{l1}}\pi^*_{W2}(\mathtt{WW})\right]}_{\equiv P_j(x_{k1},x_{l1})} - c_W x_{j1}.$$

Thus, the continuation values $P_i(x_{k1}, x_{l1})$ and $P_j(x_{k1}, x_{l1})$ of workers i and j, respectively, depend on the behavior of workers k and l in the parallel stage-1 interaction. The reason for this interdependence is that the expected equilibrium payoffs of the workers differ across the three potential stage-2 interactions SS, WW, and SW.[18] Obviously, the same holds for the continuation values $P_k(x_{i1}, x_{j1})$ and $P_l(x_{i1}, x_{j1})$ of workers k and l in the second stage-1 interaction. This implies that the two heterogeneous stage-1 interactions are linked through continuation values that are determined endogenously. This interesting technical complication is discussed in Appendix B.2 (Supporting information), where we provide a detailed closed-form solution to this setting.[19] Using stage-1 equilibrium efforts $x^*_{S1}(\mathtt{SWSW})$ and $x^*_{W1}(\mathtt{SWSW})$ by strong and weak workers, respectively, we can compute the incentive measure for setting SWSW, denoted by $\mathcal{E}(\mathtt{SWSW})$. The resulting expression reads

$$\mathcal{E}(\mathtt{SWSW}) = \underbrace{2\cdot\left[x^*_{S1}(\mathtt{SWSW}) + x^*_{W1}(\mathtt{SWSW})\right]}_{\text{stage 1 effort}} + \underbrace{2\cdot\left\{\pi^2 x^*_{S2}(\mathtt{SS}) + (1-\pi)^2 x^*_{W2}(\mathtt{WW}) + \pi(1-\pi)\left[x^*_{S2}(\mathtt{SW}) + x^*_{W2}(\mathtt{SW})\right]\right\}}_{\text{stage 2 effort}}. \tag{7}$$

In this expression, $\pi = \frac{x^*_{S1}(\mathtt{SWSW})}{x^*_{S1}(\mathtt{SWSW}) + x^*_{W1}(\mathtt{SWSW})}$ stands for the probability that a strong worker wins against the weak opponent in stage 1. This probability determines the likelihood for a particular stage-2 configuration: the stage-2 participants are both strong with probability π^2, both weak with probability $(1-\pi)^2$, and of different types with probability $2\pi(1-\pi)$. The probability π that a strong worker wins in stage 1 is

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also relevant for the selection performance of setting SWSW, $\mathcal{S}(\texttt{SWSW})$. It is defined as

$$\mathcal{S}(\texttt{SWSW}) = \pi^2 + 2\pi(1-\pi)\frac{x^*_{S2}(\texttt{SW})}{x^*_{W2}(\texttt{SW}) + x^*_{S2}(\texttt{SW})}. \tag{8}$$

Intuitively, a strong worker is promoted if either both strong workers win their stage-1 interactions, which happens with probability π^2, or if only one strong worker wins in stage 1, and subsequently also in stage 2.

3.3.3 Random Seeding

If the principal chooses the dynamic format and has no information about the productivity of the single workers, the seeding in stage 1 is random. In this case, setting SSWW occurs with probability 1/3, and setting SWSW realizes with probability 2/3. Consequently, the expected incentive provision measure for the two-stage promotion contest, denoted $\mathcal{E}(\text{II})$, is a weighted average of total effort provision in the two settings. Formally,

$$\mathcal{E}(\text{II}) = \frac{\mathcal{E}(\texttt{SSWW}) + 2\cdot\mathcal{E}(\texttt{SWSW})}{3}. \tag{9}$$

Obviously, the same holds for the selection measure $\mathcal{S}(\text{II})$, which is a weighted average of $\mathcal{S}(\texttt{SSWW})$ and $\mathcal{S}(\texttt{SWSW})$. Formally,

$$\mathcal{S}(\text{II}) = \frac{\mathcal{S}(\texttt{SSWW}) + 2\cdot\mathcal{S}(\texttt{SWSW})}{3}. \tag{10}$$

4. COMPARING INCENTIVE AND SELECTION PROPERTIES

Using the aforementioned results on equilibrium behavior of workers, we can compare one-stage and two-stage contests (I versus II) to investigate how structural modifications of the contest affect incentive provision and selection performance.

Incentive provision and selection performance are identical in the one-stage and two-stage contests if all workers are homogeneous, that is, of the same productivity. The equality in terms of selection performance follows trivially from the homogeneity assumption: either all workers are weak, and the probability that a strong worker wins is zero in both formats, or all workers are strong, and the probability that a strong worker wins is one in both formats. That the contest structure does not affect aggregate effort provision in the homogeneous case is less obvious. However, that this holds for the specification considered here has already been established by Gradstein and Konrad (1999).[20] Consequently, the comparison of these two structures in our world with heterogeneous workers allows for a rigorous investigation of the effects of heterogeneity on workers' behavior in one-stage and two-stage contests. A formal comparison of the incentive measures $\mathcal{E}(\text{I})$ and $\mathcal{E}(\text{II})$ and the selection measures $\mathcal{S}(\text{I})$ and $\mathcal{S}(\text{II})$, respectively, delivers the following proposition:

Proposition 1:
If the cost of effort is strictly higher for weak than for strong workers,

(a) *aggregate effort is strictly higher in the two-stage contest than in the one-stage contest, that is,*

$$c_W > c_S \Rightarrow \mathcal{E}(\text{I}) < \mathcal{E}(\text{II});$$

(b) *the probability that a strong agent receives the promotion is strictly higher in the one-stage contest than in the two-stage contest, that is,*

$$c_W > c_S \Rightarrow \mathcal{S}(\text{I}) > \mathcal{S}(\text{II}).$$

Proof
See Appendix C (Supporting information).

According to Proposition 1, a designer cannot improve both the incentive provision and the selection performance of a promotion contest at the same time by making the competition more (or less) dynamic. Thus, the trade-off between these two performance dimensions established by previous work cannot be solved by structural variations of the promotion contest. Modifications that improve the performance in one dimension lead to a deterioration of performance in the other dimension. In particular, we find that the two-stage contest (with random seeding) dominates the one-stage format in terms of incentive provision, whereas the opposite holds for selection performance.

Figure 2 provides a graphical illustration of the main result. Figure 2(a) plots the incentive measures of both contest formats, $\mathcal{E}(\text{I})$ and $\mathcal{E}(\text{II})$, as a function of the effort costs of weak workers, c_W, holding the

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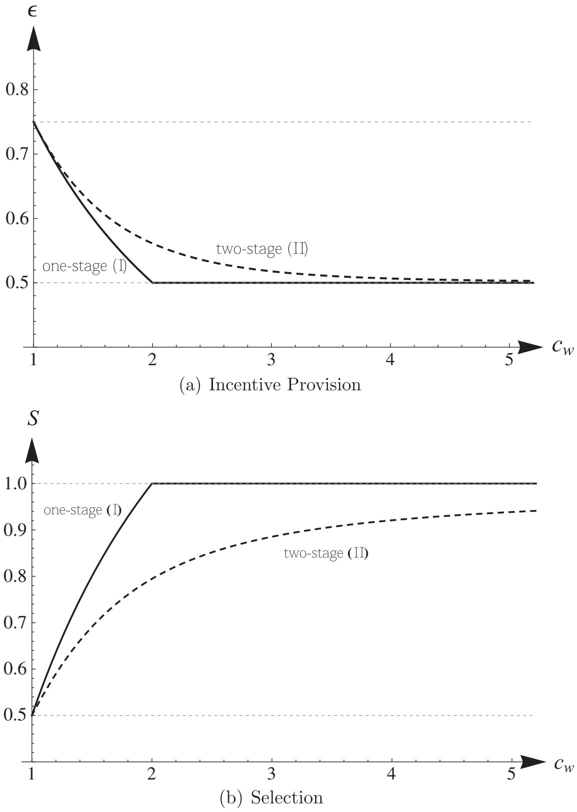

Notes: Panel (a) plots expressions (3) and (9) with $c_S = 1$ and $P = 1$; panel (b) plots (6) and (8) under the same assumption.

Figure 2. Performance in one-stage and two-stage contests.

effort costs of strong workers and the value of the promotion fixed at one ($c_{S=1}$ and $P=1$). The figure shows that the aggregate effort provision in the two-stage contest (indicated by the dotted line) is always above aggregate effort in the one-stage contest (the solid line), reflecting the statement in part (a) of Proposition 1. The difference is highest at the kink of the one-stage incentive measure (where weak workers drop out voluntarily, see Appendix A (Supporting information) for details) and decreases subsequently. For extremely high values of c_W, aggregate effort provision approaches 0.5 in both contest formats. The selection performance of both contest formats is illustrated in Figure 2(b), which plots the probability that a strong worker wins the respective contest, $\mathcal{S}(\mathrm{I})$ and $\mathcal{S}(\mathrm{II})$, as a function of the effort costs of weak workers.[21] The figure shows that the one-stage format dominates the two-stage one in terms of its selection performance, confirming part (b) of the proposition. Again, the difference between the two contest formats is highest at the kink of the one-stage selection measure where weak workers drop out and decreases for higher degrees of heterogeneity. Even if the costs of effort are five times as high for weak than for strong workers, however, the probability that a strong worker wins is still almost ten percentage points higher in the one-stage contest than in the two-stage contest. Only for extreme values of heterogeneity (when $c_W \to \infty$) $\mathcal{S}(\mathrm{II})$ approaches $\mathcal{S}(\mathrm{I})$.[22]

To understand the trade-off between the two goals we consider, one has to distinguish between *absolute* and *relative* incentives for effort provision. Relative incentives (in terms of the ratio of the workers' efforts) determine the selection performance of a contest design: the lower the equilibrium efforts of weak workers are relative to the equilibrium efforts of strong workers, the better is the selection performance of a contest. This implies that the accuracy in selection is increasing in the degree of heterogeneity between workers. Absolute incentives (i.e., the sum of the workers' efforts) determine total effort. It is well known that absolute incentives are decreasing in the degree of heterogeneity.[23] This is confirmed by our findings: in the static and dynamic contest format, total effort provision decreases when the gap between the effort costs of weak workers and those of strong workers increases. Taken together, these considerations imply that the curves for incentive provision displayed in Figure 2(a) are downwards sloping, while the curves for selection shown in Figure 2(b) are upwards sloping. These considerations are not informative about the position of one curve relative to the other, however. For this comparison, the following analogy is helpful: contest structures that amplify the degree of heterogeneity between strong and weak workers perform better in terms of selection, as heterogeneity discourages weak workers relatively more than it induces strong workers to slack off. At the same time, the more a contest design moderates the heterogeneity between types, the better is its performance in the incentive dimension, because heterogeneity decreases the incentives for effort provision for both strong and weak workers in absolute terms. Consequently, the structural variation considered in this paper works analogously to a strategic handicap-the strategic advantage of strong over weak workers is higher in the static promotion contest than in the dynamic promotion contest, which is a different way of saying that the static contest format handicaps weak workers by its structure.

5. DISCUSSION AND ADDITIONAL RESULTS

The main goal of handicapping strategies discussed in the existing literature is to reduce the adverse effect of heterogeneity on incentives. Such handicapping strategies require identification of worker types, however,

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which is often impossible. Structural handicapping has the key advantage of being feasible even if identification of abilities is impossible. Thus, it can also be used in applications where selection is of primary interest to the designer. In this case, it should be the weak rather than the strong worker who is handicapped, which is just the opposite of what the literature on handicaps for the maximization of incentive provision suggests.[24]

Recent work by Groh *et al.* (2012) suggests that the trade-off between incentive provision and selection performance disappears in some settings. They consider a two-stage pairwise elimination contest with heterogeneous contestants and investigate how the seeding of types in stage 1 affects aggregate incentives and selection performance. When comparing equilibrium behavior in settings `SSWW` and `SWSW`, they find that `SWSW` dominates in terms of incentive provision and in terms of selection performance. This result is surprising in light of the previous discussion, because the seeding of types in stage 1 can also be seen as a handicapping strategy: setting `SWSW` handicaps weak workers, as they must beat a strong competitor to stay in the contest, which simplifies the advancement of strong workers to the second round. In contrast, setting `SSWW` handicaps strong workers; they have to win against a strong competitor, while the seeding ensures that one weak worker makes it to the second stage for sure. This reasoning is confirmed by the following result, which formally compares the incentive measures $\mathcal{E}(\texttt{SSWW})$ and $\mathcal{S}(\texttt{SSWW})$ and the selection measures $\mathcal{S}(\texttt{SSWW})$ and $\mathcal{S}(\texttt{SWSW})$ for the case where workers are heterogeneous:

Proposition 2:
If the cost of effort is strictly higher for weak than for strong workers,

(a) *aggregate effort is strictly higher in setting* `SSWW` *than in setting* `SWSW`*, that is,*

$$c_{\mathrm{W}} > c_{\mathrm{S}} \Rightarrow \mathcal{E}(\mathrm{SSWW}) > \mathcal{E}(\mathrm{SWSW});$$

(b) *the probability that a strong agent receives the promotion is strictly higher in setting* `SWSW` *than in setting* `SSWW`*, that is,*

$$c_{\mathrm{W}} > c_{\mathrm{S}} \Rightarrow \mathcal{S}(\mathrm{SSWW}) < \mathcal{S}(\mathrm{SWSW}).$$

Proof
See Appendix C (Supporting information).

Hence, there is a trade-off between incentive provision and selection performance across the two settings `SSWW` and `SWSW` for the theoretical specification we consider, in contrast to what Groh *et al.* (2012) observe in their specification. This difference can be explained by properties of the contest technology. Groh *et al.* (2012) consider a perfectly discriminating contest where a marginal lead in effort translates into a sure win. Thus, weak workers must outperform their strong competitors in the effort dimension to win the competition in Groh *et al.*, while the ordinal performance measure is determined by both effort and a random component in the lottery contest considered here. The strategic disadvantage for weak workers is therefore more pronounced in the perfectly discriminating contest. This difference has no effect on the qualitative selection properties of a contest, but it does affect incentive provision: in line with what our model suggests, Groh *et al.* find that setting `SWSW` dominates `SSWW` in terms of selection. However, their results also show that setting `SWSW` dominates in the incentive dimension, in contrast to what we find in our model. Consequently, a structural handicap for strong workers has a detrimental rather than a positive impact on incentive provision in their model. While this seems surprising on first sight, it makes perfect sense intuitively. The strategic disadvantage of weak workers in the perfectly discriminating format makes it optimal to exclude all weak types from the competition-total effort is (weakly) higher in a pairwise interaction of the two strong workers than in any seeding variant of the multi-stage contest.

The previous comparison of seeding variants in two different contest models suggests that structural modifications may also be able to improve both the incentive properties and the selection performance of a contest scheme if the baseline setting induces suboptimal participation of weak types. In this special case, structural handicaps for strong workers may affect incentive provision negatively rather than positively in contests with heterogeneous workers, such that the trade-off disappears.[25] This is rather the exception than the rule in promotion contests, because participation of weak types is only suboptimal if their strategic disadvantage is extreme.

6. CONCLUDING REMARKS

This paper has investigated how structural variations of a contest affect incentive provision and selection performance in promotion contests. A comparison of static (one-shot) and dynamic (two-stage) contests suggests that the two goals are incompatible. Thus, a

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designer cannot improve both the incentive provision and the selection performance of a promotion contest by making the competition more (or less) dynamic. This implies that multiple instruments should be used whenever both goals are equally important.

Another important implication is that structural variations work like strategic handicaps. This insight is highly relevant for applications where contest schemes are either used only for incentive provision or only for selection purposes. In contrast to handicapping strategies that are discussed in the existing literature, a designer who relies on structural handicaps is not required to identify the abilities of competing workers-or at least to observe some signal of their productivities-to implement the handicap. Therefore, structural handicaps might help to improve the performance of contest schemes whenever the types of competing workers are unobservable by the designer. While the analysis in this paper compares two of the most prominent structures, it is only the first step toward a more general analysis of structural handicaps, which constitutes an interesting avenue for future research.

NOTES

1. See Welch (2001) for details. Konrad (2009) provides an extensive discussion of this example.
2. This aspect is particularly important in employment relationships plagued by moral hazard problems (Lazear and Rosen, 1981). Alternatively, the contest may serve as a commitment device for the principal (Malcomson, 1984). See Prendergast (1999) for a survey.
3. That promotion contests can help employers to select high-ability employees has previously been acknowledged in the literature—by Rosen (1986) and Waldman (1990), for example. According to Rosen, 'the inherent logic [of promotion contests] is to determine the best contestants and to promote survival of the fittest' (p.701). Somewhat surprisingly, however, Rosen's seminal paper is all about optimal incentive provision across different stages of the contest.
4. Although the exposition focuses on personnel policies and in particular on the promotion contest application, our findings are equally important for rent-seeking contests. Note, however, that the interpretation may be different in that case if effort inputs are assumed to be wasteful.
5. In their words, '…talents for the next level in the hierarchy are not perfectly correlated with talents to be the best performer in the current job' (p. 602). The best salesman, for example, can be a bad manager, which leads to the so-called Peter Principle. See also Prendergast (1993) and Bernhardt (1995), who also consider the matching performance of promotion contests.
6. The seminal paper on handicapping in heterogeneous tournaments is Lazear and Rosen (1981), and a more recent contribution that also cites some of the earlier works in this field is Gürtler and Kräkel (2010).
7. Brown and Minor (2011) provide an empirical test of the selection performance of two-stage pairwise elimination contests, which we analyze theoretically.
8. The value of being promoted may include both monetary components (promotions imply higher wages) and non-monetary aspects (e.g., concerns for status or power). Higher wages may either be chosen by the contest-designing organization, or they may result from competition between organizations. Our modeling approach is consistent both with the concept of classic promotion tournaments á la Lazear and Rosen (1981) and market-based tournaments in the spirit of Waldman (1984). For a recent comparison of these two concepts, see Waldman (2013).
9. In most professional occupations, the first promotion possibility for new hires is after one or two years. Therefore, workers who compete on the internal labor market for open positions usually know each other because of ongoing interactions in the workplace. The promotion contest for the succession of Jack Welch mentioned in the introduction , for example, lasted for 6 years.
10. In technical terms, we use a Tullock (1980) contest success function (CSF) with discriminatory power one. This format is equivalent to a perfectly discriminating CSF with multiplicative noise that follows the exponential distribution. See Konrad (2009) for details (p. 52).
11. This holds even if losers are allowed to stay in the corporation. Workers who lose the competition for a promotion are certainly discouraged, such that they often apply at different companies, that is, they will leave voluntarily.
12. After the first chosen worker has been eliminated from the pool of four workers, the probability that the next worker is of the same type is 1/3 (because only one of the remaining workers is of the same type), while the probability that the next worker is of the other type is 2/3 (because two of the three remaining workers are of the other type).
13. We model heterogeneity in terms of effort-cost differences. Results for heterogeneity in valuations or in the mapping from effort to winning probabilities are analogous. Proofs are available from the authors upon request.
14. A detailed derivation of these expressions is provided in Appendix A (Supporting information).
15. The inverse of effort costs, $\frac{1}{c_i}$, can be interpreted as a measure of i's productivity.
16. Stein and Rapoport (2004) study a framework that is similar to our `SSWW` scenario.
17. The derivation of equilibrium efforts is provided in Appendix B2 (Supporting information).
18. Conditional on reaching stage 2, workers of both types have a higher expected payoff from meeting a weak rather than a strong opponent; that is, $\Pi^*_{W2}(\mathrm{WW}) > \Pi^*_{W2}(\mathrm{SW})$ and $\Pi^*_{S2}(\mathrm{SW}) > \Pi^*_{S2}(\mathrm{SS})$. Details are provided in Appendix B.2 (Supporting information).
19. See equations (B.8) and (B.8) in Appendix B.2 (Supporting information).
20. An intuition for this result is provided by Amegashie (2000).
21. The effort costs of strong workers are again normalized to one.

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22. This is not shown in Figure 2(b), but a formal derivation is straightforward. Details are available upon request.
23. See Lazear and Rosen (1981) and Gürtler and Kräkel (2010) for theoretical work addressing this issue and Sunde (2009) or Brown (2011) for empirical evidence.
24. To our knowledge, the only exception is the paper by Ridlon and Shin (2013). They show that it can sometimes be optimal to handicap the first-round loser, even though this tends to make the second-round competition more heterogeneous and therefore less intense. The reason is that handicapping the first-round loser implies that both workers provide more effort in the first-period competition as winning this interaction is more attractive. As Ridlon and Shin show, the total effect on incentives across both periods depends on the degree of heterogeneity.
25. The expected equilibrium effort by weak workers is positive in setting `SSWW` and zero in `SWSW`. See Groh et al. (2012) for details.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web site.

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