Incentives, Information Extraction and Job Assignments*

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Abstract

We propose a two-period model with moral hazard and job assignments, where incentive design is used to extract information on assignments. *Ex ante* screening of suitability of workers to different jobs is impossible or very costly. The only way to find out the match between the worker and the task is to hire the workers and provide them with an incentive pay. Information extraction on the optimality of the job assignment is endogenously determined by the power of incentives. By setting the incentives in an appropriate way in period one, the employer may learn, in addition, to the first period output also some additional signals that may or may not reveal whether the workers are assigned to the unsuitable jobs. We argue that a deviation from a standard (myopic) incentive setting can be used to extract information on the optimality of job assignments. The main result of the paper is that some what counter-intuitively milder (low-power) incentives may extract more information.

JEL Classification: D82, L23, M54

Keywords: incentives, job design, information extraction

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1 Introduction

It is well known that ex ante screening of workers is beneficial for the employer in assigning the workers to different jobs in the organization. However, ex ante screening may be very costly, difficult or downright impossible. An often observed solution for this is that workers are hired for a probation period. Our paper answers the question how the employer should set incentives in the probation period optimally, taking into account the output effect of incentives and learning about the job-worker match.

We propose a model where incentive design is used to extract information on the optimal job assignment. The key feature of the model is that perfect *ex ante* screening of workers to match jobs is impossible. The only way to find out the "match" between a worker and a job is to hire a worker and provide him with an incentive pay. After the output and possible other signals in period one (probation, "short run") are realized, the employer has an option to reassign the workers among the jobs, i.e. to restructure the organization for period two ("long run").

As the underlying uncertainty (noise) affects realized first period output as well, a decision whether to reassign the jobs among the workers is non-trivial. Our key idea is that by providing incentives in a novel way may produce additional discrete signal(s) that may reveal whether the jobs are correctly assigned. In particular, we show that, somewhat counterintuitively, milder (low-power) production incentives in period one may reveal more information on the optimality of job assignments than stronger (high-power) incentives. This is because under the milder incentives, the workers' will not engage themselves in a complementary task within a job if workers are incorrectly assigned. This in turn creates a signal that reveals a job-worker (organizational) mismatch. The main trade-off is between the incentive provision (power of incentives) versus information extraction. Consequently, in our set up, information extraction (precision of information) is thus endogenously determined by the power of incentives.

To put our argument in perspective consider the following example. The employer needs to hire two workers (A and B) to take care of the two jobs (1 and 2). The workers look ex ante perfectly identical, say they have similar degrees, experience, etc. That is, there is no way one can know *ex ante* how they will perform in the jobs they are assigned to. Assume that job 1 has two tasks; selling to final consumers directly and providing them customer service and job 2 has similarly two tasks; selling to retailers (wholesale level) and providing them customer service. Assume also that to provide good customer service in job 1 requires more "people skills" and in job 2, in turn, it requires more "expert/marketing skills". In particular, we can think that there is a hurdle (later $x > 0$) that measures how easy it is for a worker to approach customers when he is assigned to the "wrong" job (organizational mismatch). As the two new workers look ex ante identical, it is impossible to say whether worker A (B) is more suitable for job 1 or job 2. The employer can just provide the workers high-power incentive contracts and possibly update beliefs about the optimality of job-assignments based on output and possible other signals after a period. Notice that the employer is only able to observe ex post realized sales, and as sales are affected also by a random shock (noise), it is hard to say about the optimality of job assignment. The uncertainty about the suitability of the workers to the jobs prevails. Consider now the alternative case where the employer intentionally sets milder (low-power) incentives for the workers. Interestingly in this case, the optimality of job assignments will be fully revealed since if the workers are incorrectly assigned we can expect to see customer complaints as wrongly assigned workers will not take care of their complementary customer service tasks. Whether such discrete signals (additional information) is available for the employer depends crucially on the power of incentives - under milder (low-power) incentives there will be not enough attention to customer service task as the wrongly assigned workers cannot overcome the hurdle x. Therefore low-power incentives will generate more information about the optimality of job-worker match than do the high-power incentives. In discussion section we apply our idea to screening of a desired share of workers and to venture capital financing.

In our model the employer hires two workers for the two jobs over two periods. This setup allows to calculate the profit loss from giving suboptimal (low-power) incentives in the first period and the profit gain from resolution of the uncertainty over the worker-job match in second period. In the model, the employer has a prior probability $\frac{1}{2} \leq p < 1$ that workers are correctly matched with jobs. After the first period, the employer observes output, either keeps or switches job assignments and thus has an updated probability of job assignments for the second period. We show that there exists $\widehat{p}$ such that if $p < \widehat{p}$ ($p > \widehat{p}$) a low-power (milder) incentives and perfect resolution of uncertainty is more (less) profitable than periodically optimal high-power (stronger) incentives and remaining uncertainty. Numerical analysis indicates that the threshold value $\widehat{p}$ is, ceteris paribus, increasing in the underlying production uncertainty (noise). Further comparative statics... [- When important to learn on task assignments in the long run, we should expect to see milder incentives in early on.]

Before going any further it is useful to position our paper with respect to prior literature. The notion of incentives influencing the amount of information that is revealed has been analyzed in the literature. Kaarboe and Olsen (2006) show that the principal wishes the agent not to reveal (learn) too much information on how good the agent is as the agent's incentives are determined by his career concerns. Thus it is in the principal's interest to set mild incentives. Auriol, Friebel and Pechlinavos (2002) consider a scenario where agents exert effort not only to produce output but to learn innate ability, which can increase their outside option in future. In correlated jobs, sabotage is possible and thus it may be more profitable set milder team incentives instead of individual incentives. Ichino and Muehlheusser (2008) find that it is not optimal to monitor future business partner early on too intensively as then one learns less how he will behave when not monitored.

Meyer, Olsen and Torsvik (1996) compare cases where agents are given individual or group incentives. They assume that a ratchet effect exists. This implies that agents are unwilling to exert high effort in the first period since they anticipate that the incentives for the second period take into account the each agent's revealed productivity. They find that if the ratchet effect is strong enough, a team incentive,which is milder than individual incentives, in the first period is more profitable for the principal. It allows the principal to commit to a lower-powered incentives and this in turn mitigates the ratchet effect, since then less information about the productivity of agents is revealed. However, as they remark, in their model, if the revealed productivity information would benefit the agent via improved outside option in the second period (i.e. career concerns), individual incentives would be optimal.

In contrast to papers above, in our model, information revelation (on organizational worker-job match) is profitable to the principal and does not affect the payoff of the agent, since he receives a payoff fulfilling the IR condition in expected terms always. Thus we abstract from agents' productivity differences and concentrate on the organizational (mis)match. Our results coincide with Meyer, Olsen and Torsvik (1996) in a sense that in both cases/papers milder incentives are optimal. However two important (we think) differences remain: First, in our model, milder incentives reveal more information and second, in our model the (milder) incentive that differs from the optimal static individual incentive is set dynamically optimally considering both production periods. In Meyer, Olsen and Torsvik (1996) the alternative incentive is the one that is the optimal static incentive for the team., but not optimal wrt. information revelation.

In the analysis of Arya and Mittendorf (2004) job rotation is applied to extract employee information. Specialization would bring about greater output. However, the agents will report productivity within a job more precisely if they know that in the following period they will be assigned to another job and not be punished due to ratchet effect. Ortega (2001) considers job rotation purely as a learning mechanism. Compared to our work, they utilize job rotation as the costly instrument to extract information, while in our setup this is achieved by setting sub-optimal first period incentives. The rest of the paper is structured as follows. In section 2 we describe the model in detail, and the main analysis is carried out in Section 3. In section 4 we discuss some extensions and applications of the model while Section 5 concludes.

2 The Model

2.1 Setup: Players and Technology

We consider a two-period model with moral hazard and task/job assignment problem. An employer owns the two production processes that requires two workers to take care of them. *Ex ante* at the time of hiring, the workers are perfectly identical (e.g. same degree, same experience etc.), and therefore it is not possible to assign the hired workers to those jobs that they fit in for sure, and thus the probability of an employee-job match is $1/2 \leq p < 1$. [Here we assume that the employer can try to determine the match but it remains uncertain.]

In our setup, workers' suitability for the jobs is (without loss of generality) symmetric in a sense that one worker has traits better suited to one of the jobs and the other worker to the other job, i.e. both workers are simultaneously correctly assigned with probability p and assignments are simultaneously incorrect for both of them with probability $(1-p)$.This symmetry will greatly simplify our analysis as it is therefore enough to consider one worker only. Therefore we omit indexing of the workers below.

Each job (position) involves the two tasks and for each period, the output of a worker (job) reads as $y = a + h + \epsilon$, where a is the output (effort) from the basic work assignment, h the additional output (effort) from a complementary task, and ϵ, the random production shock with $\epsilon \sim N\left(0, \sigma^2\right)$. Production thus occurs in both periods and the employer can observe only $y_t, t = 1, 2$ so a moral hazard problem exists. Furthermore and key to our model, we assume that the employer can observe whether a worker has participated in the complementary task, that is whether $h = 0$ or $h > 0$, but not the level of output from that task. [recall our motivating examples]

To model the match between a worker and a job we assume that the workers' cost of effort function takes the following form $C = \frac{1}{2}ca^2 + \gamma a\left(h + x\right) + \frac{1}{2}c\left(h + x\right)^2$, where c is the marginal cost of effort of each task, $0 \leq \gamma \leq 1$ represents the substitutability of the effort and, crucial to our model, x is the fixed amount of effort that is required in the complementary task. Our *key* assumption is that if the workers are allocated to wrong jobs in the organization, there is a personal cost, "a hurdle", $x > 0$ that the worker bears when being active also in complementary h task. If there is a match, then $x = 0$.

As we want to isolate information extraction we assume that efforts are independent, $\gamma = 0$, as then it is optimal to have each worker to be in charge of both a and h tasks in his job. That is, the cost function that we use in the analysis later on is reduced to $C = \frac{1}{2}ca^2 + \frac{1}{2}c(h+x)^2$. If the worker is assigned to the job he fits in perfectly (i.e. $x = 0$), the cost function is simply $\frac{1}{2}ca^2 + \frac{1}{2}ch^2$. This happens with probability p in first period. Alternatively, if the worker does not fit in the job, which happens with probability $(1-p)$, the cost of effort is captured by $\frac{1}{2}ca^2 + \frac{1}{2}c(h+x)^2$.

In our analysis we will focus on the two alternative ways to overcome incentive provision and job assignment problems. The employer will either maximize profits of the first period by setting optimal (myopic) incentives, then possibly revise the organization and again maximize profits of the second period. Alternatively the incentives in the first period can be set in such a way that whether the workers are correctly assigned to the jobs or not is fully revealed. The employer can then maximize profits of the second period knowing that the match in the organization is correct. Before analyzing those cases separately it is useful to spell out the employer's incentive setting problem and timing in detail.

2.2 Incentive Setting

As the only verifiable variable is realized output, y, of a worker in each period, the problem of moral hazard arises. The employer will set up an incentive pay system, and we limit our analysis to linear pay plans *a la* Holmström and Milgrom (1987) $w = by + d$, where b and d are incentive coefficient and fixed payment. The workers are assumed to be risk averse with a CARA utility function $U = -e^{-\eta(w-C)}$, where η refers to risk aversion. The employer is risk neutral and he maximizes total profits from period 1 and 2, $\pi_1 + \pi_2$, where $\pi_1 = \max_{a_1,h_1,d_1,b_1} E(y_1 - w_1 + \epsilon)$, and $\pi_2 = \max_{a_2,h_2,d_2,b_2} E(y_2 - w_2 + \epsilon)$. In each period the employer maximizes expected profits with subject to the worker's incentive compatibility and individual rationality constraints.

2.3 Timing

At the outset ($t = 0$), two workers are hired, assigned to the jobs and provided with an incentive pay. The workers choose their efforts and at the end of period one, the outputs and possible other signals are observed by the employer, and the wages are paid out. After observing realized outputs and possible other signals, the employer updates the beliefs whether agents match with the assigned jobs. Consequently then, at date $t = 1$, the employer has an option to switch the jobs among the workers. The employer then contracts with the workers again for period two. Finally at the end of period 2, the outputs are realized and wages are paid out.

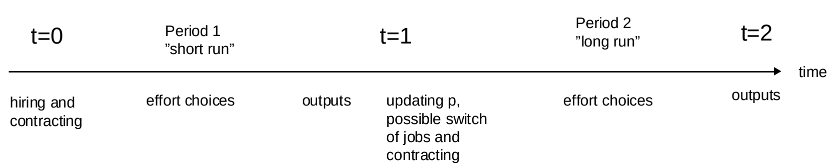

Figure 1. Timing of Events.

3 Analysis

3.1 Partial Revelation of Information

We will denote below partial revelation of information option where the uncertainty over the job-workers match will prevail with superscript u. Similarly full revelation is denoted by superscript r. Let us first consider the case where the employer maximizes profits in each period (separately), updates the beliefs of whether the jobs are correctly assigned with a possibility of reassigning them for period two. We assume that a hurdle x is small enough (see below for the exact condition for this) so that workers will participate in complementary activity h regardless of the organization match. Given the incentive pay, the worker's optimization (along his IC constraint) gives the effort choices

$$a_1^u = \frac{b_1^u}{c}, h_1^u = \frac{b_1^u - cx}{c}.$$

Recall that with probability p there is a worker-job match, i.e. $x = 0$. The expected output of a worker in period one reads

$$Ey_1^u = p\left(\frac{b_1^u}{c} + \frac{b_1^u}{c}\right) + (1-p)\left(\frac{b_1^u}{c} + \max\left\{0, \frac{b_1^u - cx}{c}\right\}\right).$$

The employer solves for the optimal incentive coefficient by maximizing expected profits

$$\begin{aligned}\max_b E\pi_1^u &= Ey_1^u - w_1^u \\ &= p\left(\frac{b_1^u}{c} + \frac{b_1^u}{c}\right) + (1-p)\left(\frac{b_1^u}{c} + \max\left\{0, \frac{b_1^u - cx}{c}\right\}\right) \\ &\quad -b_1^u\left[p\left(\frac{b_1^u}{c} + \frac{b_1^u}{c}\right) + (1-p)\left(\frac{b_1^u}{c} + \max\left\{0, \frac{b_1^u - cx}{c}\right\}\right)\right] - d_1^u\end{aligned}$$

s.t. IR: $u\left(b_1^u y_1^u, d_1^y, C_1\right) \geq U$, where U stands for the reservation utility of a worker. The optimization yields

$$b_1^{u*} = \frac{2}{2 + \sigma^2 \eta c}$$

or if $x > \frac{(1+p)}{(1+p)c+\sigma^2\eta c^2}$, $b_1^{u*} = \frac{(1+p)}{(1+p)c+\sigma^2\eta c^2}$, since for such a value of x the employer anticipates that the agent does not exert effort on the h task in the mismatched organization. We restrict our analysis below on the interesting case, where h activity is performed even then when there is a worker-job mismatch. See Appendix. Note also that the incentive coefficient, b_1^{u*} is independent of the marginal cost of effort related to the worker-job mismatch,

x. and of a priori probability of mismatch, p. The reasons for that are that regardless of the match, workers perform the h-task and that the incentive coefficient depends on the marginal of marginal effort cost, C''.

Now we can write the first period profit as

$$
\begin{aligned}
& E\pi_1^{u*}\left(b_1^{u*}=\frac{2}{2+\sigma^2\eta c}, p, x, c, \sigma^2, \eta\right) \\
= & \left(p\left(\frac{b_1^u}{c}+\frac{b_1^u}{c}\right)+(1-p)\left(\frac{b_1^u}{c}+\frac{b_1^u-cx}{c}\right)\right)-\frac{1}{2}\sigma^2\eta b_1^{u2}-\frac{b_1^{u2}}{c}-U \\
= & \frac{2b_1^u}{c}-(1-p)\,x-\frac{1}{2}\sigma^2\eta b_1^{u2}-\frac{b_1^{u2}}{c}-U
\end{aligned}
$$

3.2 Updating the worker-job match probability and possible reassignment

At date 1, before the second period, the employer observes the workers' outputs from period one. Based on that, he can either keep the job assignments or switch them. More specifically, if the updated probability that the assignment is correct is more that one half, $p_B > 1/2$, they are kept, otherwise switched. A specifies value of realized output $\overline{y_1}$ of either agent corresponds to $p_B = \frac{1}{2}$. Should the employer observe an output larger than that, he keeps assignments, but if less, he switches them. Based on Tatsuoka (1971, p.228) we find the updated probability p_B as a function of the realized output y utilizing Bayes' rule. We utilize the point probabilities of the realized output y on the distribution of output if the match is correct, $f_c(y_1^u)$ ˜$N\left(\frac{2b_1^u}{c}, \sigma^2\right)$ and on the distribution of output if there is a mismatch, $f_w(y_1^u)$ ˜$N\left(\frac{2b_1^u}{c}-x, \sigma^2\right)$

The updated probability of a match reads

$$
p_B(y_1^u)=\frac{pf_c(y_1^u)}{pf_c(y_1^u)+(1-p)f_w(y_1^u)}
$$

The level of output that corresponds to $p_B = \frac{1}{2}$, $\overline{y}_1$, satisfies $p_B(\overline{y_1}\ ) = \frac{pf_c(\overline{y}_1\ )}{pf_c(\overline{y_1}\ )+(1-p)f_w(\overline{y_1}\ )} = 1/2$.

Looking from date 0, the expected profit from period 2 depends now on expected updated probability that the assignments are correct, p_2^u . We find this probability by applying the decision rule that is derived above over the density function of the output of the first period

$p_2^u = \int_{-\infty}^{\overline{y_1}} (1 - p_B(y_1^u)) f(y_1^u) \, dy_1^u + \int_{\overline{y_1}}^{\infty} p_B(y_1^u) f(y_1^u) \, dy_1^u$, where $f(y_1^u) \sim N\left(p\frac{b_1^u}{c} + (1-p)\frac{b_1^u - cx}{c}, p^2\sigma^2 + (1-p)^2\sigma^2\right)$.

The first term corresponds to the situation where a low observation of output leads to the decision to switch the workers' assignments. In the second term, a high level of output is observed and the organization remains the same.

The profit maximization of the second period unfolds similarly to period 1. The profit from the second period reads as

$$\begin{aligned}
& E\pi_2^{u*}\left(b_2^{u*} = \frac{2}{2+\sigma^2\eta c}, p_2^u, x, c, \sigma^2, \eta\right) \\
= & \left(p_2^u\left(\frac{b_2^u}{c} + \frac{b_2^u}{c}\right) + (1-p_2^u)\left(\frac{b_2^u}{c} + \frac{b_2^u - cx}{c}\right)\right) - \frac{1}{2}\sigma^2\eta b_2^{u2} - \frac{b_2^{u2}}{c} - U \\
= & \frac{2b_2^u}{c} - (1-p_2^u)\, x - \frac{1}{2}\sigma^2\eta b_2^{u2} - \frac{b_2^{u2}}{c} - U.
\end{aligned}$$

We can already see from above (#) that the cost of remaining uncertainty over the worker-job match is $(1-p_2^u)\, x$. Looking from date 0, the expected total profits under partial revelation of information are

$$E\pi_1^{u*}\left(b_1^{u*} = \frac{2}{2+\sigma^2\eta c}, p, x, c, \sigma^2, \eta\right) + E\pi_2^{u*}\left(b_2^{u*} = \frac{2}{2+\sigma^2\eta c}, p_2^u, x, c, \sigma^2, \eta\right).$$

It is useful to notice from above that the only difference between the periods is that the expected output is higher in period 2 as the probability of a worker-job match being correct increases from p to p_2^u.

3.3 Full Revelation of Information

At date 0, the employer can consider a different approach. By setting the incentive coefficient to a certain level, he can influence the behavior of the workers in such a way that their participation to the complementary activity fully reveals whether the worker-job assignments were correct or not. In the above we assumed that the workers participated in the complementary activity regardless of the assignment. That is, $h_1^r = \left(b_1^{u*} - cx\right)/c > 0$.Consider now an incentive coefficient that is lower than the profit-maximising one, $b_1^r < b_1^{u*}$, so that now it is not optimal to the worker to participate in the complementary activity if there is a mismatch, $h_1^r = \max\left(0, \frac{b_1^r - cx}{c}\right) = 0$. This implies that is optimal for the employer to set $b_1^r = cx$ as this maximizes the expected output conditional on $h_1^r = 0$. Now can state expected profits from period one as follows.

$$\begin{aligned}
& E\pi_1^{r*}\left(b_1^r = cx, p, x, c, \sigma^2, \eta\right) \\
= \quad & \left(p\left(\frac{cx}{c} + \frac{cx}{c}\right) + (1-p)\left(\frac{cx}{c} + \frac{cx - cx}{c}\right)\right) - \frac{1}{2}\sigma^2\eta c^2 x^2 - cx^2 - U \\
= \quad & (p+1)\,x - \frac{1}{2}\sigma^2\eta c^2 x^2 - \frac{1}{2}(1+p)cx^2 - U.
\end{aligned}$$

In the second period, the employer is thus certain of the worker-job match and knows that workers perform the complementary h-task as they will not suffer from the burden of additional cost of effort due to mismatch:

$$\begin{aligned}
& E\pi_2^{r*}\left(b_2^{r*} = \frac{2}{2+\sigma^2\eta c}, p_2^r = 1, x = 0, c, \sigma^2, \eta\right) \\
= \quad & \frac{2b_2^{r*}}{c} - \frac{1}{2}\sigma^2\eta b_2^{r*2} - \frac{b_2^{r*2}}{c} - U.
\end{aligned}$$

Looking from date 0, the expected total profit under full revelation is

$$E\pi_1^{r*}\left(b_1^r = cx, p, x, c, \sigma^2, \eta\right) + E\pi_2^{r*}\left(b_2^{r*} = \frac{2}{2+\sigma^2\eta c}, p_2^r = 1, x = 0, c, \sigma^2, \eta\right).$$

3.4 What is Optimal for The Employer?

As we have now derived expressions for the total expected profits under partial and full revelation, it remains to be checked what is optimal for the employer. That is, should the employer use "high" power incentives in period 1 and thus remain uncertain about the organizational match also in period 2 as well or should he use "low" power incentives in period 1 and become then fully informed about the organizational (mis)match after which the employer can offer a normal second best contract for period 2. We thus simply have to compare the total expected profits. Notice first that necessarily there will be a profit loss associated with the full revelation option in period 1 as incentives are set suboptimally low. Also, it is equally clear that there will be a profit gain in period 2 as uncertainty over the optimal task assignment resolves within the full revelation at the end of period 1. In short, the full revelation option involves loss in profits in period 1 and gain in profits in period 2 with respect to the partial revelation option.

In order to derive the employer's optimal policy, it is useful to derive the losses and gains in detail. Consider first the losses from period 1. As we have developed earlier the expected profits we can simply evaluate the difference of expected profits (given exogenous parameters) as follows:

$$\begin{aligned}
& \Delta\pi_L\left(c, x, \sigma^2, \eta\right) \\
= \; & E\pi_1^{u*} - E\pi_1^{r*} \\
= \; & \frac{2b_1^u}{c} - (1-p)\,x - \frac{1}{2}\sigma^2\eta b_1^{u2} - \frac{b_1^{u2}}{c} - \left((p+1)\,x - \frac{1}{2}\sigma^2\eta c^2x^2 - \frac{1}{2}(1+p)cx^2\right) \\
= \; & \left(\frac{2b_1^u}{c} - 2x\right) - \left(\frac{1}{2}\sigma^2\eta\left(b_1^{u2} - c^2x^2\right)\right) - \left(\frac{b_1^{u2}}{c} - \frac{1}{2}(1+p)cx^2\right)
\end{aligned}$$

The first term in parenthesis constitutes the loss in output. The second term is the gain due to lower risk premium, and the third one corresponds to the lower cost of worker's effort, since the optimal effort is lower under the full revelation option. The larger the probability of a worker-job match, p, the larger is the profit loss from the revelation, $\frac{d\Delta\pi_L}{dp} = cxp > 0$.

Similarly, we can derive the expression for the profit gain:

$$\Delta\pi_G(p, c, x, \sigma^2, \eta) = E\pi_2^{r*} - E\pi_2^{u*} = (1 - p_2^u)\,x.$$

The explanation behind this is simple as the main advantage of the full revelation option is the increased output in the second period as the uncertainty over the worker-job match is resolved. The gain of the revelation option in turn depends on p since $p_2^u = p_2^u(p)$ and obviously $\frac{dp_2^u}{dp} > 0$. The lower is the prior probability p, ceteris paribus, the higher is the gain from revealed information.

We can summarize the above discussion as

Proposition 1 *Milder (production) incentives can extract more information and should be used when the potential benefits (or savings) from correcting the organization mismatch are high.*

As we have now gained the general understanding and intuition for the employer's optimal behavior, it is of some interest to learn also when exactly should we expect to see milder/stronger incentives in the early part of the career/working relationship to be used. In particular,

Corollary 2 *As the loss in profits is increasing in p and the gain is decreasing in p, there has to be a threshold value $\widehat{p}$ such that when $p \in [\frac{1}{2}, \widehat{p})$, it is optimal to go for the full revelation (milder/low power incentives) and when $p \in (\widehat{p}, 1)$ it is optimal to opt out for partial revelation (stronger/high power incentives)*

Rather intuitively, when it is very unlikely that the worker matches the job, it becomes more profitable to find out it. The gain from full revelation is then large because with partial revelation option, low a priori probability results in low updated probability for the second period match, and the cost of potential mismatch is high. On the other hand, loss with full revelation is small since with full revelation, low a priori probability p implies that the expected cost of effort for the complementary task in period one is low.

Corollary 3 *The threshold value $\widehat{p}$ is increasing in production uncertainty σ.*

An increase in σ affects the gain-loss trade-off in several ways. But the key channel is via the incentive coefficient $b_1^{u*} = \frac{2}{2+\sigma^2\eta c}$. High σ implies low effort and the difference in efforts between partial and full revelation decreases. Thus the loss from full revelation decreases. When the loss is compared with the gain from full revelation, a higher match probability $p_2^u(p)$ and thus higher a priori probability $\widehat{p}$ satisfies the equation.

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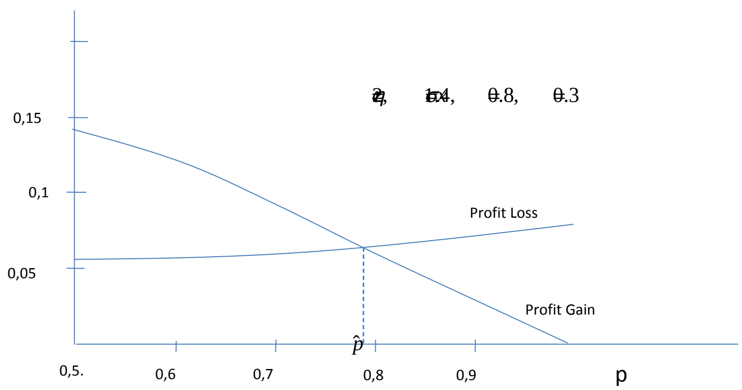

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Figure 2: Comparison of profit losses and gains.

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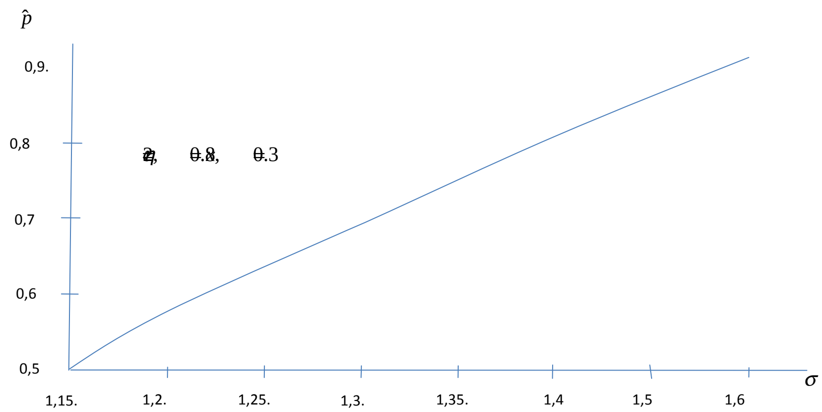

$_3$.*pdf*

Figure 3: Threshold value $\widehat{p}$ as a function of ucertainty σ.

Raises a new question: how much to invest in increasing prior probability. there exists a p for which the above paths generate equal profits. might be reasonable to analyze since the effect on profits is only through p_2^u...

4 Discussion and Extensions

4.1 Separating An Optimal Share of Worker Population

Consider a military organization. Its structure is quite rigid and stable. So the employer knows beforehand the number of junior officers that will be promoted to senior rank. The precision of the selection is important. If the separated population is smaller than the planned one, either fixed investments in education remain unused or the employer must increase the group randomly and the average ability suffers. If the separated group is larger than planned, the average ability suffers from random discard from the group. The idea of our model can be applied to such a situation. Agents now have heterogeneous individual productivity. This implies that a ratchet effect or career concerns may appear, but we abstract from those. Say that the employer wants to separate after the first period those z percent of workers for additional training that are most suitable for it. Let us assume that each worker i has a heterogenous hurdle x_i to engage himself in the complementary task h . If the workers are given the profit-maximising incentive b^*, either too many or too few workers perform the h task. The employer knows the distribution of the 'hurdle' of workers and for the desired z share of suitable workers, the highest 'hurdle' is x_z. Instead of setting the optimal incentive b^*, the employer sets an incentive cx_z. Thus he suffers a loss in the first period since the incentive is not the one that maximizes profits. In the second period, the employer gains since the separated group of workers matches the available resources and they are exactly the group with highest average ability.

4.2 Venture Capital Financing[1]

Another setting where our analysis has potentially a bite comes from the Venture Capital (VC) financing. Prior literature has pointed out at least two dimensions in which VC financiers are special. VC financiers are regarded to have due to their gained expertise special skills in terms of screening the projects and finance applicants (, i.e. entrepreneurs(E)) ex ante and then providing those entrepreneurs that receive funding advice and assistance in implementing the projects. The ultimate goal of any venture capitalist is to provide funding to Es only for a limited time and then exit as profitably as possible, i.e. to get as large compensation for its equity stake as possible when exiting.

[1] We thank Ari Hyytinen for suggesting us to think about our model in terms of VC finance.

But even if the VC financier has an expertise in screening entrepreneurs/projects it may come across with the following problem in the spirit of our paper. The projects VC typically gets involved with have roughly speaking two phases; developing an initial idea to a product (engineering phase) and then bringing it successfully to the market/consumers (marketing phase). It is quite likely that it is *ex ante* very difficult to say whether E with a product idea would be the one that would have both "technical" and "people" skills in order to master both phases in the best possible way. We can thus think that there are Es that are also market (commercially) oriented. In particular, this question is highly relevant as often it is the case that E who has developed the idea in the first place wishes not to leave his idea at this stage but rather (partially due to the nontransferable private benefits) prefers to carry on developing it to commercially viable product even though it would (under certain conditions) be socially optimal to let some other E (or outside marketing agency) to take care of this second task.

The question then becomes, if VC faces a problem just described, how could this be reflected in the (financial) contract between VC and E. Notice that now in contrast to our model VC faces a single E in a two-period setting, but is uncertain whether E is the right agent to implement the second task (marketing) as well. We thus assume that in period one there are two phases. Assume also along the lines of our model that potential Es are equally good in implementing a technological (engineering) phase but differ in their marketing abilities ("people skills"). In terms of our model, the second marketing task can be assumed to involve a personal hurdle x to some Es. As VCs payoff from exiting a venture depends on the market value of it at the time of exiting it is clearly in the VC's interest to try to learn about the E's type and possibly try to influence that the second, marketing phase would be taken care of a separate outside marketing expert/agent as that would maximize the market value of the venture.

Could it be that milder incentives work better in extracting information about the E's suitability to the 2nd period marketing task also here? We know for sure that high-power incentives (high stake) are needed for E to take an appropriate (innovative) effort and making the innovation as a commercially viable product. Following our setup, high-power incentives come with a cost as it may prevent the VC from learning E's type as both types are willing to take up marketing due to high compensation. Instead, milder incentives may reveal that an E is not the suitable one for taking care of the marketing task. Thus trade-off takes now a slightly different yet similar form as low-power incentives in addition of being sub-optimal also imply a lower probability of appearance of commercially successful product but will anyhow reveal to the VC whether the current E is not the one that has marketing ("people") skills as well. Ideally it would be optimal if technologically oriented E would take care of innovation stage and then the other, market oriented E would take care of the final stage in developing a commercially viable product. How this could be implemented via contracting is a challenging question. One solution would be conditioning the allocation of control over the project on the signal learned by VC after the first period. Then if the VC learns that no commercially promising product has been developed, a new E (or outside marketing agency) is hired to take of the second task. Of course, this possibility will be anticipated by the first E and will thus affect his behavior as well.

5 Conclusion

In this paper we have presented a model where information extraction on the optimality of job assignment is endogenously determined by the power of incentives. Our key finding is that sub-optimal milder incentives may be more profitable since they extract more information on job assignment than stronger incentives. Our analysis assumes that milder incentives generate additional discrete signals that can be used to find out optimal job assignments. We think of a situation where the myopic first period incentive is such that agents perform the h-task also in the case of organization mismatch. Then a milder incentive results in information revelation. Under other parameters, the static incentive may be such that h-task is not performed even in the correct organization match. In that case a stronger incentive reveals information. In our setup, information revelation increases the principals profits in the second period and agents always remain at their IR level. This implies that the principal is willing to trade off profits in the first period to extract more precise information. Since the agent does not entertain strategic motives, the contracts that the principal offers for both periods are similar regardless whether he can commit to both contracts initially or not. Consider situations where the information affects also the agents payoff in the second period and where the principal cannot commit to contracts to both periods. A career concern view is that high output in the first period signals high personal productivity and that the agent can benefit from this information via e.g. an improved outside option. In our setup, this would mean that the principal's goal of increasing the precision of an organization match through mild incentives is contrary to the agent's desire to show high output. The ratchet effect view tells us that the agent is not willing to reveal personal productivity because the principal can condition the second period incentives based on this. In this case, organization match information revelation through mild incentives is parallel to the agent's interest to hide personal productivity.

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6 Appendix 1

In a rational expectations equilibrium (REE), expectations must be consistent with the realization. If the employer expects that h task is performed, the optimal incentive reads $b_1^{u*} = \frac{2}{2+\sigma^2\eta c}$ and if he expects that it is not performed, $b_1^{u**} = \frac{(1+p)}{(1+p)+\sigma^2\eta c}$.For $x > \frac{2}{2c+\sigma^2\eta c^2}$, it is obvious that regardless of the employer's expectations, the worker does not perform the h task. Likewise, for $x < \frac{(1+p)}{(1+p)c+\sigma^2\eta c^2}$, he will perform, again regardless of expectations. What if $\frac{(1+p)}{(1+p)c+\sigma^2\eta c^2} \leq x \leq \frac{2}{2c+\sigma^2\eta c^2}$? We show that of the two possible

REE, the employer chooses the the one where he expects the the worker does not perform the h task and this is realized if $\sigma^2\eta c < \frac{(p+1)^2}{2-2p}$. The profit functions of the cases read

$$\pi_{u1}(b_1^{u*} = \frac{2}{2+\sigma^2\eta c}, h > 0) = \left[p\left(\frac{b_1^{u*}}{c} + \frac{b_1^{u*}}{c}\right) + (1-p)\left(\frac{b_1^{u*}}{c} + \frac{b_1^{u*}-cx}{c}\right)\right] - \frac{1}{2}\sigma^2\eta b_1^{u*2} - \frac{1}{2}c\left[p\left(\frac{b_1^{u*2}}{c^2} + \frac{b_1^{u*2}}{c^2}\right) + (1-p)\left(\frac{b_1^{u*2}}{c^2} + \left(\frac{b_1^{u*}-cx}{c} + x\right)^2\right)\right] - U$$

$$\pi_{u2}(b_1^{u**} = \frac{(1+p)}{(1+p)+\sigma^2\eta c}, h = 0) = \left[p\left(\frac{b_1^{u**}}{c} + \frac{b_1^{u**}}{c}\right) + (1-p)\left(\frac{b_1^{u**}}{c} + 0\right)\right] - \frac{1}{2}\sigma^2\eta b_1^{u**2} - \frac{1}{2}c\left[p\left(\frac{b_1^{u**2}}{c^2} + \frac{b_1^{u**2}}{c^2}\right) + (1-p)\left(\frac{b_1^{u**2}}{c^2} + 0\right)\right] - U$$

To show that $\pi_{u2} > \pi_{u1}$, we evaluate the profits at the lowest level of x, $x = \frac{b_1^{u**}}{c} = \frac{(1+p)}{(1+p)c+\sigma^2\eta c^2}$. Manipulation of the inequality yields

$$(1+p)\frac{b_1^{u**}}{c} - \frac{1}{2}\sigma^2\eta b_1^{u**2} - \frac{1}{2}(1+p)\frac{b_1^{u**2}}{c} > 2\frac{b_1^{u*}}{c} - (1-p)x - \frac{1}{2}\sigma^2\eta b_1^{u*2} - \frac{b_1^{u*2}}{c}$$

and further

$LHS = (1+p)\frac{b_1^{u**}}{c} - \frac{1}{2}\sigma^2\eta b_1^{u**2} - \frac{1}{2}(1+p)\frac{b_1^{u**2}}{c} + (1-p)\frac{b_1^{u**}}{c} > 2\frac{b_1^{u*}}{c} - \frac{1}{2}\sigma^2\eta b_1^{u*2} - \frac{b_1^{u*2}}{c} = RHS$. We note that for $p = 1$, $LHS = RHS$. Thus, if $\frac{d(LHS)}{dp} < 0$ for $\frac{1}{2} \leq p < 1$, we know that $LHS > RHS$ since the value of RHS is independent of p. Differentiation yields $\frac{d(LHS)}{dp} = \frac{b_1^{u**}}{c} - \frac{1}{2}\frac{b_1^{u**2}}{c} +$

$\frac{d((1-p)\frac{b_1^{u**}}{c})}{dp}$. The envelope theorem yields the first two terms. $\frac{d(LHS)}{dp} = \frac{1}{c}(-\frac{1}{2}b_1^{u**2} + (1-p)\frac{db_1^{u**}}{dp}) = \frac{1}{c}(-\frac{(1+p)^2}{2((1+p)+\sigma^2\eta c)^2} + \frac{(1-p)\sigma^2\eta c}{((1+p)+\sigma^2\eta c)^2})$. We find that $\frac{d(LHS)}{dp} < 0$ if $-p^2 - p(2 + 2\sigma^2\eta c) - 1 + 2\sigma^2\eta c < 0$. This holds for $\frac{1}{2} <$

$p < 1$ if $\sigma^2 \eta c < 2\frac{1}{4}$. More specifically it holds when $p > -1 - \sigma^2 \eta c \mp \sqrt{(\sigma^2 \eta c)^2 + 4\sigma^2 \eta c}$ or alternatively $\sigma^2 \eta c < \frac{(p+1)^2}{2-2p}$.