Rewarding Idleness*

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Abstract

Market wages reflect expected productivity conditional on signals of past performance and past experience. These signals are generated at least partially on the job and create incentives for agents to choose high-profile and highly visible tasks. When engaging in visible tasks can lead to losses for which the agent is not liable, a principal may profitably distort corporate investments and reward schemes to increase the opportunity cost of these tasks. This distortion may decrease welfare as it prevents the efficient discovery of workers' talent. Heterogeneity in employee types induces substantial diversity in organizational and contractual choices, particularly regarding the extent to which conspicuous activities are tolerated or encouraged, the composition of corporate infrastructure, and contingent wages.

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1 Introduction

A young employee's productivity is rarely perfectly known, and often requires a long period of hands-on experience before being fully revealed. If an employee can be allocated to different tasks, then the time required for her productivity to be revealed will be affected by the employer's choice of task allocation. For example, a young employee may be asked to engage in a new, challenging project which, in case of success, will reveal that this employee is highly productive. Or she may be asked to work on routine tasks, to remain idle, or to rest, which are tasks that do not reveal information about the employee's ability. From the social point of view, it may be beneficial to choose tasks that reveal as fast as possible the productivity of each worker. However, if the benefit of learning the productivity of each worker cannot be fully captured by firms, then the equilibrium task allocation and organizational choice is likely to be distorted toward short-run profits, possibly leading to less-than-optimal learning.

In this paper, we formalize this intuition in a model of on-the-job talent discovery. In our model, employees have an incentive to engage in tasks that generate public signals about their abilities, even when engaging in these tasks decreases the firm's profit. Employers respond to these incentives by adjusting their reward schemes and corporate 'infrastructure' to affect the opportunity costs of different tasks. Similarly to Terviö (2009), the rate of talent discovery of young agents may be inefficiently low because, in equilibrium, fewer young people than optimal are employed. Novel to our approach and central to our analyses, the rate of talent discovery of agents who are employed (i.e., on-the-job talent discovery) may also be inefficiently low, because the choice of task allocation within the firm may be distorted.

We find that the equilibrium rate of on-the-job talent discovery – and the inefficiency associated with it – differs across workers. In a partial equilibrium framework, we show that a firm optimally allocates a worker to the most informative task if, and only if, both the worker's benefit from talent discovery and her market value are sufficiently high. The reason is that generating information about the worker by task allocation imposes a cost on the firm. Only a worker with high market value can compensate for this cost by accepting a lower wage. As a consequence, workers with a high value of talent discovery but low market value will be either inefficiently unemployed, or employed but inefficiently allocated to uninformative tasks. By solving for the market value and the benefit of talent discovery of each worker, we then show that intermediate productivity types benefit the most from talent discovery, but are also the most likely to be inefficiently allocated to uninformative tasks, especially the ones close to the employability threshold.

Finally, we find that heterogeneity in employees' career concerns translates into heterogeneity of firms' optimal organizational choices, in particular with respect to whether employees are encouraged or discouraged to engage in activities that publicly reveal their talent. Indeed, in our model the optimal contractual and corporate infrastructure choices change discontinuously in the strength of employees' career concerns, so that small differences in employees' type can cause large differences in firms' organizational choices. Note that within-industry heterogeneity in organizational form, corporate infrastructure, and contractual choice is well-documented empirically (see, e.g., Gibbons, 2010, for a survey). Our model can therefore help explaining one particular dimension of this heterogeneity: the extent to which firms encourage, tolerate, or sanction their workers' participation in activities that reveal skills and signal productivity, such as experimenting in new tasks, engage in difficult projects, or competing with coworkers.[1]

Hence, our model predicts that some firms may allocate workers to tasks that reveal their talent but are not profit maximizing. Evidence by Perlow and Porter (2009) suggests that, indeed, career concerns may distort the task allocation implemented by a principal in a way that is consistent with our prediction. They report on a four-years experiment at several offices of the Boston Consulting Group, where "people believe that a 24/7 work ethic is essential for getting ahead, so they work 60-plus hours a week and are slaves of their BlackBerry." (Perlow and Porter, 2009, p. 1). The treatment consisted in forcing people to take time off, i.e. re-allocating time from working to idleness. Each member of the treatment teams had to leave the office without access to email or BlackBerry for a period of either one full day or one evening per week, depending on the version of the treatment. The project was met with strong resistance by the consultants, who would have preferred to continue working. The effect of the treatment was that participants reported "more open communication, increased learning and development, and a better product delivered to the client" (Ibid. p. 4). That is, incentives to discover and signal talent and productivity appear

[1] Indeed, management practices differ substantially in terms of whether firms expect and encourage overtime work (e.g., by providing free food and a taxi home when working late), use systematic performance monitoring, or leave employees discretion over their own task allocation. See also the cross-country evidence collected by Bloom and Van Reenen (2007).

to have affected working behavior, task choice, and, ultimately, output.

To formalize our argument we use a principal-agent model. Agents' productivities are unknown, but their expected values are publicly observable. An agent chooses to perform one of two tasks. One task, called a, is complex, its outcome is uncertain, and its probability of success depends on the agent's productivity. Its outcome is publicly observable, generating a signal about the agent's productivity. Its expected return depends on the state of the world, and may exceed or fall short of the expected return to the other task, called b. Task b is routine and its outcome is independent of the agent's productivity. We normalize the return to task b to zero, so that this task is best interpreted as remaining idle. In contrast, task a is best interpreted as starting a new project, initiating a merger, or launching a marketing campaign. We allow the state of the world (and the return to task a) to be common knowledge, or private information of the agent (i.e., the agent has expert knowledge). In the first case, a contract in effect conditions the task choice on the state of the world. In the second case, a principal uses payments contingent on task choice and investments in corporate infrastructures to affect the agent's opportunity cost of each task. In both cases a principal can use two types of contracts: a *flexible contract*, inducing the agent to choose a task conditional on the state of the world, or a *rigid contract*, inducing the agent to unconditionally choose a specific task.

Because an agent lives for two periods, choosing the visible task when young affects the agent's expected productivity and payoff when old. That is, agents have career concerns, which are stronger the less informative the prior belief about their productivity. Career concerns generate heterogeneity in contractual and organizational choice for the young. Young agents who have high market value, high expected productivity, and thus relatively low career concerns ("proven talents") receive flexible contracts. These contracts implement the profit-maximizing task choice and efficient investment. Young agents of intermediate expected productivity ("high potentials") have intermediate market value and derive high value from talent discovery. Since a flexible contract that balances incentives is very costly, a principal hiring a "high potential" uses a rigid contract implementing the visible task regardless of its return. This regime corresponds to organizations that emphasize demonstrating ability, e.g., by working long hours. Finally, agents with low expected productivity and low market value but strong career concerns ("hidden gems") receive flexible contracts.

In the first two cases, on-the-job talent discovery is efficient. For "hidden gems" instead, talent discovery is inefficiently low. Using rigid instead of flexible contracts for "hidden gems" increases aggregate surplus, because a rigid contract generates information regarding the agent's productivity independently on the state of the world, while a flexible contract generates information only in some states of the world. However, limited liability prevents the agent from compensating the principal for the loss in expected profits caused by switching to a rigid contract.

The logic of the model extends beyond corporate organizational choice. For example, physicians' salaries may depend on measures of ability such as report cards (see e.g. Kolstad, 2013, Varkevisser, van der Geest and Schut, 2012), generating incentives to signal ability. Interestingly, some health care plans in the U.S. explicitly reward physicians for inactivity by way of bonuses, fee withholds, and expanded capitation (see Orentlicher, 1996).[2] In addition to contracts that reward inactivity, other forms (e.g., capitation or fee-for-service) are also widely used, generating substantial contractual heterogeneity. Our results also extend to cases in which the non-visible task is productive (see Section 5.3), such as academia. Interpreting teaching as a non-informative task and research as a visible task, our results suggest that young academics spend too much time teaching, which prevents them from efficiently revealing their research skills to the market. Note also that, in line with our predictions, universities have substantial contractual heterogeneity with respect to rewards for teaching and research. Finally, we consider the possibility that the employer has the same (or better) information about the payoffs of the different tasks than the employee. This applies for example to plane pilots and professional athletes. Their task allocation (i.e. when they should rest) is either specified in the contract (for pilots), or is chosen directly by the employer (the athlete's club or manager). That is, if the worker does not have private information the principal will simply enforce idleness (instead of rewarding it). We consider this case in an extension, Section 5.2.

The paper is organized as follows. The remainder of this section discusses the relevant literature. Section 2 introduces the theoretical framework. Section 3 solves a benchmark version of the model without limited liability. In that version, the equilibrium contractual and organizational forms of each firm depends only on the value of talent discovery of its worker, which is therefore efficient. Section 4 introduces limited liability and shows that firms will distort their contractual and organizational choice so to reduce some workers'

[2] Bonuses, fee withholds, and expanded capitation can be described roughly as follows: if the total cost of treatments prescribed by a physician falls short of the pre-specified amount, the physician receives a bonus payment.

talent discovery below the efficient level. Section 5 discusses several extensions of the model, and section 6 concludes. Appendix A contains all mathematical derivations that are missing from the main text. Appendix B considers the case of large, heterogeneous firms.

1.1 Related Literature

The paper that is most closely related to our is Terviö (2009), in which the productivity of a young agent who enters the labor market is unknown ex-ante, and is revealed if this agent is hired by a firm. Without long-term contracts, liquidity constraints lead then to less-than-efficient entry into the labor market and inefficient discovery of the productivity of workers who are not hired. Our paper complements this analysis by introducing talent discovery through task allocation and organizational choice and showing that talent discovery may be inefficiently low also on the job. Also close to our paper, Harstad (2007) analyzes how a firm's organizational choice depends on the visibility of a manager's ability. By design firms extract the full value of signaling and therefore increase transparency and lower the manager's compensation whenever talent increases its market value. In our model, limited liability and asymmetry of information create a wedge between the objectives of firms and of workers: talent discovery (and signaling) is inefficient.

This paper belongs to the literature on career concerns and incentives (see Gibbons and Murphy, 1992), which has described distortions in principal-agent settings due to career concerns, such as excessive or too little risk taking (Hermalin, 1993, Hirshleifer and Thakor, 1992), over-investment in or under-usage of information (Scharfstein and Stein, 1990, Milbourn et al., 2001), over-provision of effort (Holmström, 1999), or distorted project choice (Holmström and Ricart i Costa, 1986, Narayanan, 1985). Closer to our model, Kaarbøe and Olsen (2006) introduce career concerns in a multi-task setting a la Holmström and Milgrom (1991). Similarly to our model, they show that the principal may use task-specific monetary incentives to balance the agent's career concerns. Also related is Pitchik (2008), who considers different types of investments and shows that a worker will be biased toward self-promoting activities – that is, investments that can be observed by outsiders. Our paper focuses on the resulting inefficiency in talent discovery and organizational heterogeneity, not discussed in Kaarbøe and Olsen (2006) nor in Pitchik (2008). Canidio and Legros (2013) also consider a multi-task setting with career concerns. They argue that inefficient on-the-job task allocation and talent discovery may induce workers to become entrepreneurs. Entrepreneurs may earn less than workers of equivalent characteristics, but they have full control on their task choice, and can efficiently choose task that reveal their talent.

Our paper also contributes to the literature on productivity-enhancing investment or non-monetary rewards such as perks. Perks have been interpreted as non-monetary remuneration substituting for cash payments (see, e.g., Rosen, 1986). Here, we argue that perks are both a form of remuneration and a way to affect an employee's optimal task choice. Perks have also been described as arising from managerial discretionary power over free cash flow (see, e.g., Jensen, 1986, Bebchuk and Fried, 2009, Rajan and Wulf, 2006). By contrast, in our setup the principal decides on the provision of perks, which are then enjoyed by the agent, as part of an optimal incentive system. Finally, previous work has examined the use of perks to create incentives for workers (see, e.g., Kvaløy and Schöttner, 2015, Marino and Zábojník, 2008, Oyer, 2008), but has focused mainly on a single-task environment, remaining silent on issues of tailoring corporate investments to task choice.

Heterogeneity of organizational forms and productivities is also a result in Gibbons, Holden and Powell (2012) and Legros and Newman (2013). In both papers, the output price determines firms' organizational choices, which in turn affect the price. In Gibbons, Holden and Powell (2012) the market price conveys a signal about the aggregate state of the world, which leads some firms to choose organizational forms that generate information and others to free-ride on the information contained in the market price. In Legros and Newman (2013), the market price determines the severity of nontransferabilities within firms, which in turn determine ownership choices. Heterogeneity in ownership is necessary to generate a continuous aggregate supply function and guarantees the existence of the competitive equilibrium. Our paper complements their analysis, exploring the heterogeneity in the choices of corporate infrastructure and labor contracts in response to career concerns.

2 The Model

2.1 Agents

An economy is populated by a continuum of heterogeneous agents $i \in I$ and a continuum of identical principals $j \in J$. Both agents and principals are endowed with measure 1. Agents are born with zero wealth, live for two periods denoted by $\tau \in \{y; o\}$, and are heterogeneous in their productivity type $p \in \{\underline{p}; \overline{p}\}$ with $0 < \underline{p} < \overline{p} < 1$. Productivity is unobservable to both agents and principals. Denote a young agent's expected productivity by

$$\tilde{p} = E[p|\tau = y].$$

The expectation $\tilde{p}$ is best interpreted as credentials generated at an un-modeled earlier stage, e.g., grades at school. Denote an old agent's expected productivity by

$$\tilde{p}_o = E[p|\tau = o],$$

For any agent, $\tilde{p}_o$ depends on $\tilde{p}$ and on the work performance in the first period of life. We assume that young agents do not discount future payoffs.

2.2 Production

Principals and agents jointly generate output in firms of size 2 (see section 5.4 for an extension to greater firm sizes). Setting up a firm requires a fixed cost F. In a firm the agent works on one of two tasks $d \in \{a, b\}$. Task b is a routine task that yields revenue 0 for the principal.[3] In contrast, task a is complex and may be completed successfully (S) or result in a failure (F). The probability of success in task a is given by the agent's productivity p.

Our main assumption is that the revenues generated in case of success or failure depend on a firm- and period-specific state of the world $s \in \{A, B\}$, with $\text{pr}(s = A) = q$ and $\text{pr}(s = B) = 1 - q$. Hence, task a is best interpreted as starting a new project, such as developing a new product, which requires the principal to commit some of the company's resources. These resources will be lost if the agent fails. If instead the agent succeeds, the product is launched. This setup allows for the interesting case where revenues are maximized by task a in state A and by task b in state B. Call the revenue in case of success $\overline{R}(s)$ and the revenue in case of failure $\underline{R}(s) < \overline{R}(s)$. Let $R(s, p) = p\overline{R}(s) + (1 - p)\underline{R}(s)$ denote the expected revenue in state s given productivity p. We assume that

$$R(A, p) > 0 \geq R(B, p) \text{ for all } p \in \{\underline{p}; \overline{p}\}. \tag{A1}$$

This assumption captures situations in which the product may flop and fail to break even, quality problems may hurt the firm's reputation, or design flaws may trigger legal actions and fines.

[3] This extreme case, where b is unproductive and uninformative (i.e., staying idle) effectively illustrates our main point: career concerns generate diversity in organizational choice and may lead firms to reward idleness. Our results carry over qualitatively when the revenue from task b is positive, see Section 5.3.

Finally, in the body of the text we assume that the state of the world is the agent's private information.[4] That is, the agent has expert knowledge about the expected profitability of task a (e.g., a manager with private knowledge about the profitability of a restructuring).[5] For ease of exposition, suppose that the agent has full information about the state s, while the principal only knows the prior. Finally, success and failure are publicly revealed at the end of each period, as in Harris and Holmström (1982).

2.3 Corporate Investments in Infrastructure

When performing a given task, an agent incurs a task-specific utility cost c_d. As in Oyer (2008), this cost can be affected by the principal's investments, which are denoted by k_a and k_b:

$$c_b(k_b) = -k_b \text{ and } c_a(k_a) = c - k_a.$$

k_a represents investment in corporate infrastructure complementary to production, such as office space, powerful computers, and high quality furniture, which will be referred to as A capital. In contrast, k_b is investment in corporate infrastructure complementary to idleness, such as swimming pools, climbing walls and game rooms, which will be referred to as B capital. Note that k_a and k_b may capture investments in corporate culture, which determine, for instance, the extent to which an agent's successful performance is rewarded by social esteem. The cost of either investment is convex, and given by $(k_a^2 + k_b^2)/2$ for notational convenience. Let

$$c > q. \tag{A2}$$

This assumption guarantees that, whenever the investment level in A capital is chosen efficiently, performing task a is costly for the agent. Finally, suppose that the setup cost F is high enough to render idle firms unprofitable in the sense that the total surplus is negative if the agent chooses task b with certainty: $F \geq 1/2$.

[4] Section 5.2 considers the case of common knowledge, in which the choice over task allocation can be delegated to the principal.

[5] Note that this case is also consistent with interpreting s as the agent's physical state (which, for instance, may reflect health or alertness) if the agent has private information about the state, conditional on all observables such as previous workload.

2.4 Contractual Environment and Payoffs

In a firm (i, j), contracts specify the principal's investments (k_a, k_b) and payments $w_d \geq 0$ contingent on tasks $d = \{a, b\}$. Because agents have no wealth, contracts must respect limited liability and induce non-negative payments. Task choice and the outcome of task a are publicly observable, but revenue and the state of the world are not verifiable at the time of wage payments.[6] Individuals can only sign short-term contracts. Contracts may condition on an agent's age.

Hence, in each period a matched agent obtains payoff $u = w_b + k_b$ if the task chosen was b and $u = w_a - c + k_a$ if it was a. Correspondingly, a principal's payoff is $\pi = -w_b - \kappa$ if task b was chosen and $E[\pi] = R(s, \tilde{p}) - w_a - \kappa$ otherwise, where $\kappa = F + (k_a^2 + k_b^2)/2$.

2.5 Timing of Events

In each period, events in this economy unfold as follows:

1. Principals and agents match in a frictionless labor market, and sign binding short-term contracts.
2. Principals invest as specified in the contract.
3. Within each match (i, j), a state of the world $s \in \{A, B\}$ is realized.
4. The agent chooses task a or task b.
5. Successes and failures in task a are realized, revenue accrues, and payments are made.

A labor market equilibrium is an individually rational, stable allocation of pairs of one principal and one agent, such that there is no pair of principal and agent who can obtain a strictly higher joint payoff if they match and sign a contract of the form (k_a, k_b, w_a, w_b).

In each period t, a measure 1 of principals competes for a measure 1 of agents, with measure 1/2 of young and old agents each. Suppose that the distribution of young agents' expected productivities $\tilde{p}$ has full support on $[\underline{p}, \overline{p}]$. This assumption suffices to guarantee the stationarity of our simple labor market.

[6] Allowing the state to be contractible will leave our results qualitatively unchanged in the presence of limited liability. Because the principal cannot impose a negative transfer on the agent, she will still reward task b to prevent the agent from choosing task a in state B.

3 A Constrained Efficient Benchmark

We start by examining a simplified version of the model without imposing limited liability, i.e., payments w_a and w_b can be negative. We will show that investments and task choice depend only on agents' career concerns (and not on their market value) and are therefore efficient conditional on these concerns. This case thus serves as an efficient benchmark, corresponding to the allocation chosen by a social planner who maximizes aggregate utility but cannot observe agents' productivities.[7] Furthermore, the simplification allows to illustrate the mechanism at work without the additional complication of nontransferable utility induced by limited liability, which is examined in Section 4 below.

We distinguish between a *rigid* contract implementing task a independently of the state of the world and a *flexible* contract implementing task a in state A and task b in state B.[8] Hence, a rigid contract generates a signal about a worker's type in every state of the world, while a flexible contract generates a signal only in state A. We show that, in this constrained efficient benchmark, young agents of intermediate productivity type benefit the most form generating information and are therefore allocated to a rigid contract if hired. All other workers are instead allocated to a flexible contract, which is the contract maximizing output in each period. Investments in k_a and k_b depend only on the type of contract offered, so that any two agents both receiving a rigid (or a flexible) contract enjoy the same level of non-monetary benefits.

3.1 Old Agents

We examine the case of an old agent first, because the expected payoffs when old will determine the career concerns when young. Consider a principal matched with an agent $\tilde{p}_o$ having outside option $\underline{u}$ (which will be derived endogenously as the equilibrium market payoff). Incentive compatibility of a flexible contract requires the agent to be indifferent between tasks a and b, that is

$$w_a - c + k_a = w_b + k_b.$$

[7] In a first best, when agents' productivities are observable, there are neither career concerns nor contractual and organizational heterogeneity.

[8] A contract implementing task b independently of the state of the world yields negative surplus as $F > 1/2$. A contract implementing task a in state B and task b in state A generates negative expected surplus because of Assumption A1.

The participation constraint is

$$q(w_a - c + k_a) + (1 - q)(w_b + k_b) \geq \underline{u}.$$

Incentive compatibility implies that the payoffs in each state have to be individually rational: $w_b + k_b \geq \underline{u}$ and $w_a - c + k_a \geq \underline{u}$. The principal's expected payoff is

$$\pi = q(R(A, \tilde{p}_o) - w_a) - (1 - q)w_b - (k_a^2 + k_b^2)/2 - F. \tag{1}$$

As the principal's payoff decreases in w_a, w_b, k_a and k_b, the participation constraint has to bind and

$$w_b + k_b = \underline{u} = w_a - c + k_a.$$

That is, payments are $w_a = \underline{u} + c - k_a$ and $w_b = \underline{u} - k_b$. Using this result on (1) yields

$$\pi = q(R(A, \tilde{p}_o) - c + k_a) + (1 - q)k_b - (k_a^2 + k_b^2)/2 - F - \underline{u}.$$

Therefore, investment choices $k_a = q$ and $k_b = 1 - q$ maximize both the principal's payoff conditional on the agent's outside option $\underline{u}$ and the joint payoff.

Consider now a rigid contract. Incentive compatibility and individual rationality require

$$w_a - c + k_a \geq w_b + k_b \text{ and } w_a - c + k_a \geq \underline{u},$$

respectively. The principal's expected payoff is

$$\pi = qR(A, \tilde{p}_o) + (1 - q)R(B, \tilde{p}_o) - c - w_a - w_b - (k_a^2 + k_b^2)/2 - F. \tag{2}$$

To maximize π, the principal chooses $k_b = 0$ and $w_b = 0$, and the participation constraint must bind. Using this on (2) implies that $k_a = 1$, which also maximizes the joint payoff of principal and agent. The wage for task a is then $w_a = \underline{u} + c - 1$.

Inspecting the payoffs of a principal and an old agent, a flexible contract Pareto dominates a rigid one if $R(B, \tilde{p}_o) - (c - q) < 0$, which is implied by Assumptions A1 and A2. The joint payoff under a flexible contract is positive only if

$$\tilde{p}_o \geq \frac{c - q + 1 + \frac{F}{q} - \frac{1}{2q} - \underline{R}(A)}{\overline{R}(A) - \underline{R}(A)} := \bar{p}_o^*.$$

That is, $\bar{p}_o^*$ denotes the minimum productivity required by a principal hiring an old agent with $\underline{u} = 0$. We assume that a flexible contract with efficient investments is profitable for old agents with high productivity $\overline{p}$, but not for those with low productivity $\underline{p}$:

$$R(A, \underline{p}) < c - q + 1 + F/q - 1/(2q) < R(A, \overline{p}). \tag{A3}$$

Therefore old agents with $\tilde{p}_o < \bar{p}_o^*$ remain unmatched and productive agents are scarce. Hence, principals compete for agents who can generate positive expected output, and obtain zero profits in equilibrium. This observation pins down the labor market equilibrium payoffs for old agents (which must equal the outside option $\underline{u}$ in each match):

$$u_o^*(\tilde{p}_o) = \begin{cases} q(R(A, \tilde{p}_o) - c) + \frac{q^2+(1-q)^2}{2} - F & \text{if } \tilde{p}_o \geq \bar{p}_o^*, \\ 0 & \text{if } \tilde{p}_o < \bar{p}_o^*, \end{cases} \tag{3}$$

3.2 Career Concerns

In contrast to old agents, young agents have career concerns, because failing or succeeding at task a provides an informative signal about their productivity. Consider a young agent with expected productivity $\tilde{p}$. Denote the posterior expectation of $\tilde{p}$ by $p_I(\tilde{p})$ if the agent remained idle in period 1, by $p_F(\tilde{p})$ if the agent failed at task a, and by $p_S(\tilde{p})$ if the agent succeeded. Applying Bayes's formula yields the following statement.

Lemma 1. *An old agent's expected productivity is $p_S(\tilde{p}) = \bar{p} + \underline{p} - \frac{\bar{p}\,\underline{p}}{\tilde{p}}$ after task a was successfully completed, $p_F(\tilde{p}) = \frac{\tilde{p}(1-\underline{p}-\bar{p})+\bar{p}\underline{p}}{1-\tilde{p}}$ after a failure to complete task a, and $p_I(\tilde{p}) = \tilde{p}$ otherwise.*

Clearly $p_F(\tilde{p}) < p_I(\tilde{p}) = \tilde{p} < p_S(\tilde{p})$. Denote by $s^*(\tilde{p})$ the value of the signal generated by a young agent with expected productivity $\tilde{p}$ in task a. Because individuals are risk neutral, the signal value is given by

$$s^*(\tilde{p}) = \tilde{p}u_o^*(p_S(\tilde{p})) + (1 - \tilde{p})u_o^*(p_F(\tilde{p})) - u_o^*(\tilde{p}). \tag{4}$$

Recall that an old agent's equilibrium payoff $u_o^*(\tilde{p}_o)$ (given by 3) is increasing, is piecewise linear, and has a kink at $\bar{p}_o^*$. It follows that

$$s^*(\tilde{p}) = \begin{cases} \tilde{p}u_o^*(p_S(\tilde{p})) & \text{if } \tilde{p} \leq \bar{p}_o^* < p_S(\tilde{p}) \\ \tilde{p}u_o^*(p_S(\tilde{p})) - u_o^*(\tilde{p}) & \text{if } p_F(\tilde{p}) < \bar{p}_o^* < \tilde{p} \\ 0 & \text{otherwise.} \end{cases}$$

Hence, $s^*(\tilde{p}) \geq 0$ for all $\tilde{p} \in [\underline{p}; \bar{p}]$, strictly increases on $\tilde{p} < \bar{p}_o^* < p_S(\tilde{p})$, and strictly decreases on $p_F(\tilde{p}) < \bar{p}_o^* < \tilde{p}$, implying that $s^*(\bar{p}_o^*) > 0$. That is, generating a public signal has a positive value for agents with productivity $\tilde{p}$ in the neighborhood of $\bar{p}_o^*$.

Note that this result holds also if the agents are averse to risk. In general the value of generating a public signal decreases in the degree of the agents' risk aversion, but is always positive in the neighborhood of $\bar{p}_o^*$. All the results in the next sections depend on the fact that the signal value $s^*(\tilde{p})$ is somewhere positive, and thus will be qualitatively unchanged by introducing risk aversion.

3.3 Young Agents

The contractual choice for young agents will respond to career concerns. We start again with a flexible contract. Incentive compatibility and individual rationality require

$$w_a + s^*(\tilde{p}) - c + k_a = w_b + k_b \text{ and } q(w_a + s^*(\tilde{p}) - c + k_a) + (1-q)(w_b + k_b) \geq \underline{u},$$

where $\underline{u}$ denotes again the agent's outside option. The principal's payoff is

$$\pi = q(R(A,\tilde{p}) - w_a) - (1-q)w_b - (k_a^2 + k_b^2)/2 - F. \tag{5}$$

Similar to the case of old agents, investments will be chosen efficiently, $k_a = q$ and $k_b = 1-q$. Associated payments are $w_a = c + \underline{u} - q - s^*(\tilde{p})$ and $w_b = \underline{u} - (1-q)$.

For a rigid contract incentive compatibility and individual rationality require

$$w_a + s^*(\tilde{p}) - c + k_a \geq w_b + k_b \text{ and } w_a + s^*(\tilde{p}) - c + k_a \geq \underline{u}.$$

The principal's payoff is

$$\pi = qR(A,\tilde{p}) + (1-q)R(B,\tilde{p}) - w_a - (k_a^2 + k_b^2)/2 - F.$$

Also here $k_b = 0$, $w_b = 0$, $k_a = 1$, and $w_a = \underline{u} + c - s^*(\tilde{p}) - 1$. Note that career concerns lower the monetary payment to the young agent and reduce the cost of implementing a rigid contract.

Therefore young agents require less remuneration than old agents of the same productivity, especially if they expect to be allocated to task a. Compared with the labor market equilibrium for old agents, the presence of career concerns has two effects. On the one hand, a rigid contract may Pareto dominate a flexible one for a young agent if the signal value $s^*(\tilde{p})$ is sufficiently high. On the other hand, young agents are employed at lower productivity than old agents, because young agents with expected productivity in the neighborhood of $\bar{p}_o^*$ value the signal generated by task a, which partly compensates their effort cost c. The following proposition summarizes these results.

Proposition 1 (Benchmark Equilibrium Allocation)**.** *Old agents with $\tilde{p}_o$ are matched and receive a flexible contract if $\tilde{p}_o \geq \bar{p}_o^* > 0$, and remain unmatched otherwise. Their equilibrium payoffs $u_o^*(\tilde{p}_o)$ are given by (3).*

Young agents with $\tilde{p}$ derive positive value from generating a signal, $s^*(\tilde{p}) \geq 0$, with $s^*(\tilde{p}) > 0$ for $\tilde{p}$ in the neighborhood of $\bar{p}_o^*$. They are matched to a principal if $\tilde{p} \geq \bar{p}_y^*$ with $\bar{p}_y^* < \bar{p}_o^*$. They receive a flexible contract if $c - q - s^*(\tilde{p}) \geq R(B, \tilde{p})$ and a rigid contract otherwise. Young agents with $\tilde{p} < \bar{p}_y^*$ remain unmatched.

The equilibrium allocation maximizes aggregate surplus.

To assess whether rigid contracts are used in the benchmark equilibrium and, if so, who uses them, we note that $s^*(\tilde{p})$ converges to 0 as $\tilde{p}$ approaches $\overline{p}$ and that flexible contracts are used for high productivity agents. Given that $s^*(\tilde{p})$ attains a maximum at $\bar{p}_o^*$, we derive the following statement.

Proposition 2 (Benchmark Organizational Choice)**.** *Suppose that $R(B, \tilde{p})$ is sufficiently close to 0 for $\tilde{p} \in [\underline{p}, \overline{p}]$ and that $q < c$ is sufficiently close to c. Then there are thresholds $\bar{p}_y^* \leq p_1^* < p_2^* < \overline{p}$ such that the optimal contract for a young agent is*

(i) flexible for $\bar{p}_y^* \leq \tilde{p} \leq p_1^*$,

(ii) rigid for $p_1^* \leq \tilde{p} \leq p_2^*$,

(iii) flexible for $p_2^* \leq \tilde{p} \leq \overline{p}$.

If $q \geq 1/2$, the break-even young agent receives a rigid contract, i.e. $\bar{p}_y^* = p_1^*$. Else, the break-even young agent receives a flexible contract, i.e. $\bar{p}_y^* < p_1^*$.

That is, career concerns can generate organizational and contractual heterogeneity in firms that employ young agents.

4 Labor Market Equilibrium with Limited Liability

We now turn to the equilibrium behavior of principals and agents when contracts have to respect limited liability (i.e., $w_a, w_b \geq 0$). Compared with the equilibrium of the benchmark model discussed in the previous section, now the equilibrium contract and investment levels received by an agent may depend on his market value. Therefore investments may be distorted downwards simply because the agent cannot pay for them. More subtly, for young agents who receive a flexible contract, the mix of investments may be biased towards B capital to compensate for the signal value. That is, idleness may be rewarded by means of corporate investment. As a consequence, relative to our benchmark, now a young agent is less likely to work on task a, especially if he has low market value, leading to less-than-optimal talent discovery. In addition, organizational heterogeneity emerges within each contractual regime, as the optimal investment changes with the worker's outside option. Finally, a firm's preferred contractual regime may change multiple times between flexible and rigid as $\tilde{p}$ increases.

To solve for the optimal contract, we consider again a pair of principal and agent with an outside option $\underline{u}$ and signal value $s(\tilde{p})$, which will later be derived endogenously as the market equilibrium payoffs.

4.1 Old Agents

As above, we start with the problem for old agents, for whom the signal value is zero. A principal who uses a flexible contract maximizes the payoff

$$\pi = q(R(A, \tilde{p}_o) - w_a) - (1-q)w_b - (k_a^2 + k_b^2)/2 - F,$$

subject to incentive compatibility and individual rationality

$$w_b + k_b = w_a - c + k_a \text{ and } q(w_a - c + k_a) + (1-q)(w_b + k_b) \geq \underline{u}.$$

As above the participation constraint has to bind. Recall that $k_a = q$ is the efficient investment in A capital. Compensating the agent in kind by increasing k_a is cheaper for the principal than using a cash payment whenever $k_a < q$. Because $q < c$, setting $k_a = q$ and $w_a = \underline{u} + c - q$ satisfies limited liability. In contrast, efficient investments in B capital (that is $k_b = 1 - q$ and $w_b = \underline{u} - (1-q)$) are compatible with limited liability only if $\underline{u} \geq 1 - q$. Otherwise $k_b = \underline{u}$ and $w_b = 0$. That is, under a flexible contract both types of investments are provided, but only to the extent required to satisfy the participation constraint. Limited liability may induce under-investment in B capital for old agents. As in the benchmark case the optimal contract takes the form of a base salary and a bonus for task a.

Consider now a rigid contract. Incentive compatibility and individual rationality require

$$w_a - c + k_a \geq w_b + k_b \text{ and } w_a - c + k_a \geq \underline{u},$$

The principal's payoff is

$$\pi = qR(A, \tilde{p}_o) + (1-q)R(B, \tilde{p}_o) - c - w_a - w_b - (k_a^2 + k_b^2)/2 - F.$$

As above $k_b = 0$, $w_b = 0$, and the participation constraint binds. Efficient investment in A capital ($k_a = 1$ and $w_a = \underline{u} - 1 + c$) satisfies limited liability only if $\underline{u} \geq 1 - c$. Otherwise, $k_a = \underline{u} + c$ and $w_a = 0$. A rigid contract thus discourages idleness and is accompanied by substantial investment in A capital but not in B capital. Under-investment in A capital compared with the benchmark is possible for agents with low outside options.

Comparing individual payoffs under the different contractual regimes yields the following statement.

Proposition 3. *In a match of a principal and an old agent, under assumptions A1 and A2 a flexible contract is preferred to a rigid contract. An old agent is hired only if*

$$\begin{aligned} &q(R(A, \tilde{p}_o) - c) + (q^2 + (1-q)^2)/2 - F \geq \underline{u} && \text{if } \underline{u} \geq 1 - q, \\ &q(R(A, \tilde{p}_o) - c) + q^2/2 - F \geq q\underline{u} + \underline{u}^2/2 && \text{if } \underline{u} < 1 - q. \end{aligned}$$

Corporate investments k_a and k_b coincide with the benchmark if $\underline{u} \geq 1 - q$, otherwise there is under-investment in k_b.

As in the benchmark, flexible contracts always dominate rigid ones under Assumptions A1 and A2. Old agents are employed only if their expected productivity is high enough and they all receive flexible contracts. Limited liability distorts investments for low outside options $\underline{u} < 1 - q$. Therefore, the minimum productivity required to break even in expectation is higher here than in the benchmark. Agents who generate positive surplus are again scarce, so that principals obtain zero profits in equilibrium. This determines old agents' equilibrium payoffs.

Proposition 4. *In a labor market equilibrium, all old agents with expected productivity $\tilde{p}_o \geq \bar{p}_o$ are employed and obtain flexible contracts, with*

$$\bar{p}_o = \frac{c - q/2 + F/q - \underline{R}(A)}{\overline{R}(A) - \underline{R}(A)} > \bar{p}_o^* > \underline{p}. \tag{6}$$

There is $\hat{p}_o > \bar{p}_o$, such that investments are efficient if $\tilde{p}_o \geq \hat{p}_o$. In equilibrium principals obtain payoffs $\pi = 0$ and old agents obtain payoffs

$$u_o(\tilde{p}_o) = \begin{cases} q(R(A, \tilde{p}_o) - c) + \frac{q^2 + (1-q)^2}{2} - F & \text{if } \tilde{p}_o \geq \hat{p}_o, \\ \sqrt{2q(R(A, \tilde{p}_o) - c + q) - 2F} - q & \text{if } \bar{p}_o < \tilde{p}_o < \hat{p}_o, \\ 0 & \text{if } \tilde{p}_o < \bar{p}_o. \end{cases} \tag{7}$$

In other words, under limited liability unemployment is higher than in the benchmark, and the payoffs of intermediate productivity types' are lower.

4.2 Career Concerns

As above, old agents' payoffs (7) determine a young agent's signal value $s(\tilde{p})$:

$$s(\tilde{p}) = \begin{cases} \tilde{p} u_o(p_S(\tilde{p})) & \text{if } \tilde{p} < \bar{p}_o < p_S(\tilde{p}), \\ \tilde{p} u_o(p_S(\tilde{p})) - u_o(\tilde{p}) & \text{if } p_F(\tilde{p}) < \bar{p}_o < \tilde{p}, \\ \tilde{p} u_o(p_S(\tilde{p})) + (1-\tilde{p}) u_o(p_F(\tilde{p})) - u_o(\tilde{p}) & \text{if } \bar{p}_o < p_F(\tilde{p}) < \hat{p}_o, \\ 0 & \text{otherwise.} \end{cases}$$

Note here that, in contrast to the benchmark, $s(\tilde{p})$ may be negative because old agents' payoffs are a concave function of $\tilde{p}_o$ for $\bar{p}_o < \tilde{p}_o < \hat{p}_o$. Differentiating $u_o(\tilde{p}_o)$, $p_S(.)$, and $p_F(.)$ implies the following properties.

Lemma 2 (Signal Value)**.** *Given old agents' equilibrium payoffs, the signal value* $s(\tilde{p})$

(i) is strictly positive and strictly increases for $\overline{p}\,\underline{p}/(\overline{p} + \underline{p} + \bar{p}_o) < \tilde{p} < \bar{p}_o$*,*

(ii) strictly decreases for $\bar{p}_o < \tilde{p} < (\bar{p}_o - \overline{p}\underline{p})/(1 - \overline{p} - \underline{p} - \bar{p}_o)$*,*

(iii) increases for $\tilde{p} > \max\{\bar{p}_o, (\bar{p}_o - \overline{p}\underline{p})/(1 - \overline{p} - \underline{p} - \bar{p}_o)\}$*.*

Figure 1 illustrates Lemma 2 and compares the equilibrium signal value to the benchmark signal value (i.e. the signal value without limited liability). Indeed the signal value increases for low $\tilde{p}$, decreases for some intermediate $\tilde{p}$ and increases again for sufficiently high $\tilde{p}$.

4.3 Young Agents

The contracting problem of a principal and a young agent with expected productivity $\tilde{p}$ is complicated both by limited liability and career concerns. For now we take as given the signal value $s(\tilde{p})$ and the agent's outside option $\underline{u}$. To derive the market equilibrium we will then allow both $\underline{u}$ and $s(\tilde{p})$ to be endogenous, exploiting the fact that in equilibrium each agent's participation constraint is binding.[9] Also, in equilibrium necessarily $\underline{u} \geq s(\tilde{p}) - c$, because an agent who is hired has always the option to work on task a if he wishes.

The incentive compatibility constraint of a flexible contract requires

$$w_a + s(\tilde{p}) - c + k_a = w_b + k_b.$$

[9] That is, in a market equilibrium with a continuum of types, each agent's payoff is their "market payoff": the payoff they would receive if they were to match with any principal.

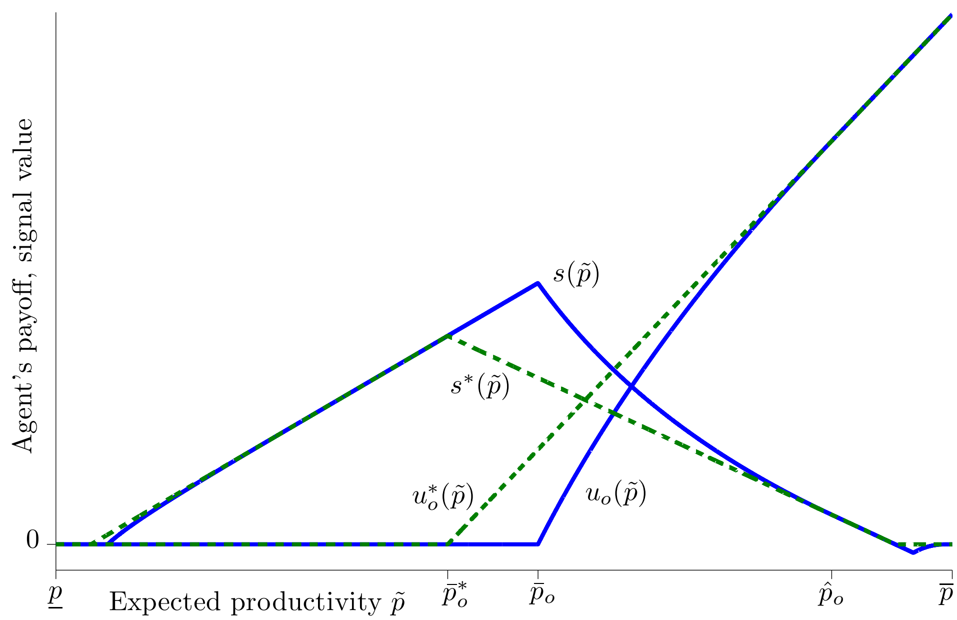

Fig. 1: Old agents' payoffs and young agents' signal value in equilibrium (solid lines) and benchmark (dashed lines).

The agent's participation constraint is given by

$$q(w_a + s(\tilde{p}) - c + k_a) + (1-q)(w_b + k_b) \geq \underline{u}. \tag{8}$$

The principal's payoff is

$$\pi = q(R(A, \tilde{p}) - w_a) - (1-q)w_b - (k_a^2 + k_b^2)/2 - F. \tag{9}$$

Because the participation constraint is binding, it is again cheaper to transfer utility in kind if $k_a < q$ and $k_b < 1 - q$, such that

$$\begin{array}{ll} w_a = 0, k_a = \underline{u}+c-s(\tilde{p}), w_b = 0 \text{ and } k_b = \underline{u} & \text{if } \underline{u}+c-s(\tilde{p}) < q \\ w_a = \underline{u}+c-s(\tilde{p})-q, k_a = q, w_b = \underline{u}-(1-q) \text{ and } k_b = 1-q & \text{otherwise.} \end{array} \tag{10}$$

Career concerns bias the agent toward the visible task a. A flexible contract balances against this bias by providing adequate incentives for task b. Specifically, the contract makes task a relatively more costly than b by using an appropriate mix of investments and monetary incentives. For young agents with low outside options, the provision of B capital satisfies the participation constraint. To ensure incentive compatibility the principal then optimally biases investments toward B capital.

If a rigid contract is used to implement a for a young agent, incentive compatibility and individual rationality require

$$w_a + s(\tilde{p}) - c + k_a \geq w_b + k_b \text{ and } w_a + s(\tilde{p}) - c + k_a \geq \underline{u}.$$

The principal's payoff is

$$\pi = qR(A, \tilde{p}) + (1-q)R(B, \tilde{p}) - w_a - (k_a^2 + k_b^2)/2 - F.$$

Therefore the principal optimally sets $k_b = 0$ and $w_b = 0$. Analogous to the case of a flexible contract, because the participation constraint is binding in-kind transfers in the form of the investment k_a are more profitable than cash payments as long as $k_a < 1$, as in the case of old agents. Therefore,

$$\begin{array}{ll} w_a = 0 \text{ and } k_a = c - s(\tilde{p}) + \underline{u} & \text{if } c - s(\tilde{p}) + \underline{u} \leq 1, \\ w_a = c - s(\tilde{p}) + \underline{u} - 1 \text{ and } k_a = 1 & \text{otherwise.} \end{array} \tag{11}$$

Rigid contracts emphasize investment in A capital and do not provide B capital. They rely primarily on implicit incentives to encourage employees to choose task a. Monetary payments are used only for agents with sufficiently high outside options. Comparing payoffs under rigid and flexible contracts yields the following statement.

Lemma 3. *For a young agent with expected productivity $\tilde{p}$ and outside option $\underline{u} \geq s(\tilde{p}) - c$, a rigid contract dominates a flexible contract if, and only if, both outside option $\underline{u}$ and the signal value $s(\tilde{p})$ are sufficiently large, that is, if both*

(i) $\underline{u} \geq \hat{u}(\tilde{p})$, for a cutoff value $\hat{u}(\tilde{p})$, with $\hat{u}(\tilde{p}) > 0$ if $R(B, \tilde{p}) < 0$, and

(ii) $s(\tilde{p}) \geq \hat{s}(\underline{u})$, where $\hat{s}(u)$ is a decreasing function on $[\hat{u}(\tilde{p}), +\infty)$ approaching $c - q - R(B, \tilde{p})$ in the limit.

Corporate investments in A and B capital maximize the joint surplus given contractual choice if $\underline{u} \geq q$, and $\underline{u} \geq 1 - q$, respectively.

That is, rigid contracts are used for young agents with strong career concerns and good outside options. High outside options are necessary to make rigid contracts preferable under limited liability, because the agent needs to compensate the principal for the decrease in expected revenue ($R(B, \tilde{p})$ instead of 0) through a lower wage.

Interpreting the outside option $\underline{u}$ as an agent's market value, Lemma 3 allows us to tie contractual and organizational choice to an agent's characteristics. *High potentials* (who have both high market and high signal value) receive rigid contracts that discourage idleness and emphasize task a. Corporate investment focuses on A capital. *Hidden gems* (who have low market but high signal value) receive flexible contracts and corporate investments are distorted to discourage signal generation on the job. Organizations may efficiently invest in B capital while under-investing in A capital. Such organizations emphasize the possibility of staying idle and discourage employees from activities that generate public signals. Finally, *proven talents* (who have low signal value) receive flexible contracts. Idleness is tolerated but not explicitly rewarded. Investment in A capital is efficient, and B capital is used to reward the agent but not to affect task choice.

4.4 Equilibrium Organizational Choice

Next we determine the structure of organizational and contractual choice in a labor market equilibrium, which will depend on payoffs. A young agent's equilibrium payoff $u_y(\tilde{p})$ can be derived using the fact that $\pi = 0$. Indeed, $u_y(\tilde{p})$ strictly increases in $\tilde{p}$ (see the proof of Lemma 4 in the appendix). Hence, there is a unique productivity level $\bar{p}_y$ such that under a flexible contract $u_y(\tilde{p}) \geq 0$ for $\tilde{p} \geq \bar{p}_y$ and $u_y(\tilde{p}) < 0$ otherwise. Because the participation constraint is binding, $u_y(\tilde{p}) = 0$ implies $s(\tilde{p}) \leq c$. Hence $\bar{p}_y$ is pinned down by

$$q(R(A, \bar{p}) - w_a) - k_a^2/2 - F = 0, \tag{12}$$

with $w_a = 0$ and $k_a = c - s(\bar{p}_y)$ if $s(\bar{p}_y) < c - q$, and $w_a = c - q - s(\bar{p}_y)$ and $k_a = q$ otherwise. By Lemma 3 a flexible contract dominates a rigid one for small payoffs $u_y(\tilde{p}) \leq \hat{u}(\tilde{p})$ with $\hat{u}(\tilde{p}) \geq 0$. This finding implies the next statement.

Lemma 4. *There is $\bar{p}_y$ such that all young agents with $\tilde{p} \geq \bar{p}_y$ are hired by a principal. For $\tilde{p}$ close to $\bar{p}_y$ this contract is flexible. Young agents are hired by principals at lower productivity levels than old agents: $\bar{p}_y < \bar{p}_o$. Their payoff $u_y(\tilde{p})$ strictly increases for $\tilde{p} \geq \bar{p}_y$.*

As in the benchmark model, young agents are employed at lower productivity levels than old agents. Contrary to the benchmark case the marginal young agent (with $\tilde{p}$ close to $\bar{p}_y$) always receives a flexible contract, *independent of his signal value.* The reason is that under limited liability a young agent has no means to compensate the principal for the expected losses generated by working on task a in state B. Hence, the agent will be allocated a flexible contract even when the benefit of learning his talent is very large.

We now turn to the organizational choice of firms hiring young workers with productivity above $\bar{p}_y$. By Lemma 3 young agents obtain rigid contracts if they have both sufficient equilibrium payoff $u_y(\tilde{p})$ and signal value $s(\tilde{p})$. Both are endogenous and, in equilibrium, depend on each other because the signal value is part of a young agent's payoff. Specifically, by Lemma 3 for a high enough payoff $u_y(\tilde{p})$, a rigid contract is chosen if the signal value exceeds a threshold $\hat{s}(u_y(\tilde{p}))$. This threshold decreases in $\tilde{p}$ because $u_y(\tilde{p})$ is strictly increasing. Because of the shape of $s(\tilde{p})$ (see Lemma 2), there may be several intersection points, and the optimal organizational choice may switch back and forth between flexible and rigid contracts as $\tilde{p}$ increases from $\bar{p}_y$ to $\overline{p}$. The following proposition states that rigid contracts may be used for intermediate productivity workers, while the most and least productive workers receive a flexible contract.

Proposition 5 (Labor Market Outcome)**.** *In a labor market equilibrium, old agents obtain flexible contracts if $\tilde{p}_o \geq \bar{p}_o$ and stay idle otherwise, and young agents obtain flexible or a rigid contracts if $\tilde{p} \geq \bar{p}_y$ and stay idle otherwise.*
If $R(B, \tilde{p})$ is sufficiently close to 0 and c is sufficiently close to q there are thresholds $p_y < p_1 < p_2 \leq p_3 < p_4 < \overline{p}$ such that the optimal contract for a young agent is:
(i) flexible for $\bar{p}_y < \tilde{p} < p_1$ with $w_a = 0$, $0 < k_a \leq q$, and $0 < k_b \leq 1 - q$,
(ii) rigid for $p_1 < \tilde{p} < p_2$ and $p_3 < \tilde{p} < p_4$ with $w_a \geq 0$, $q < k_a \leq 1$, and $k_b = 0$,
(iii) flexible for $p_3 < \tilde{p} < \overline{p}$ with $w_a > 0$, and $k_a = q$, and $0 < k_b \leq 1 - q$.

For young agents with low productivity, $\bar{p}_y < \tilde{p} < p_1$, career concerns are strong, but the associated market payoff is low. These agents receive flexible contracts with underinvestment in k_a used to discourage task a. This case describes the hidden gems mentioned above. Young agents with $p_1 < \tilde{p} < p_2$ are high potentials, with strong career concerns and intermediate market values, which allows them to compensate the principal for the expected revenue loss when using a rigid contract. This contract may take the extreme form of $k_a < 1$ and $w_a = w_b = 0$, which is reminiscent of unpaid internships that are common, for example, in journalism. Finally, young agents with high productivity have weak career concerns and high market value. Thus, proven talents obtain flexible contracts

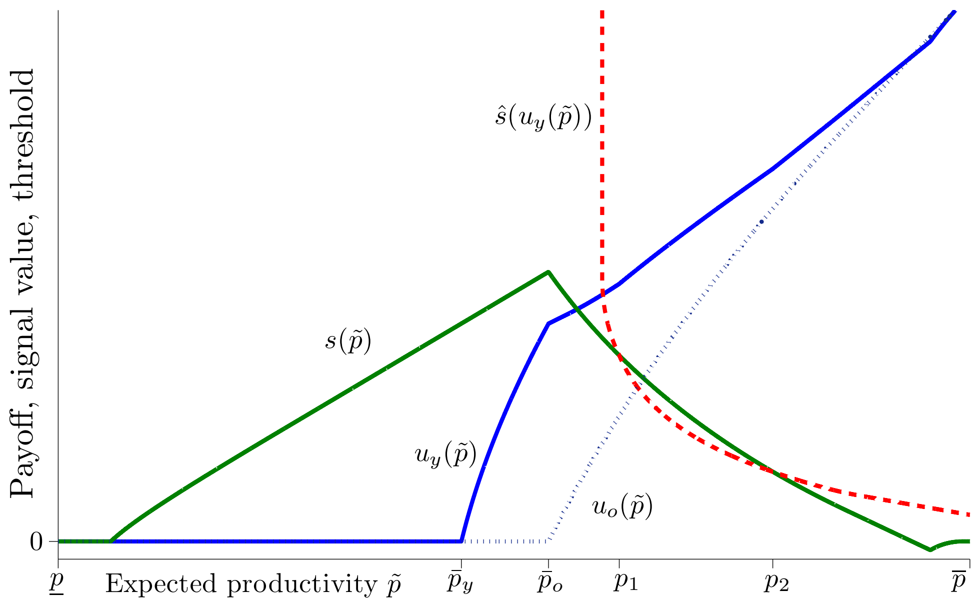

Fig. 2: Contractual and organizational choice depending on expected productivity $\tilde{p}$.

with efficient investment in k_a and possibly in k_b. Figure 2 summarizes these points and also shows the signal value threshold $\hat{s}(.)$, which determines the different regimes.

Contracts for agents with $\bar{p}_y < \tilde{p} < \bar{p}_o$ are an extreme form of discouraging work and rewarding idleness, especially when $u_y(\bar{p}_o) > 1 - q$, since then $w_b > 0$, but $w_a = 0$. Such a contract pays a wage only if the agent remains idle, but if the agent remains idle she will be unemployed when old. If the agent chooses task a and generates a signal, no wage is paid and the agent will either move up to a better contract with a potentially different employer, or move out and remain unemployed.

Finally, there is organizational heterogeneity across generations. Figure 3 depicts the equilibrium corporate infrastructure investment for old and young agents at different productivity levels. As in the benchmark model, for young agents the investment is discontinuous whenever the contractual regime changes. A young agent receiving a flexible contract enjoys higher k_b (e.g., sports facilities or game rooms) and lower k_a (e.g., office equipment or corporate jets) relative to an old agent with the same productivity. Young agents who receive rigid contracts enjoy lower k_b than old agents with the same productivity. Therefore, the composition of corporate investment differs substantially across generation, even

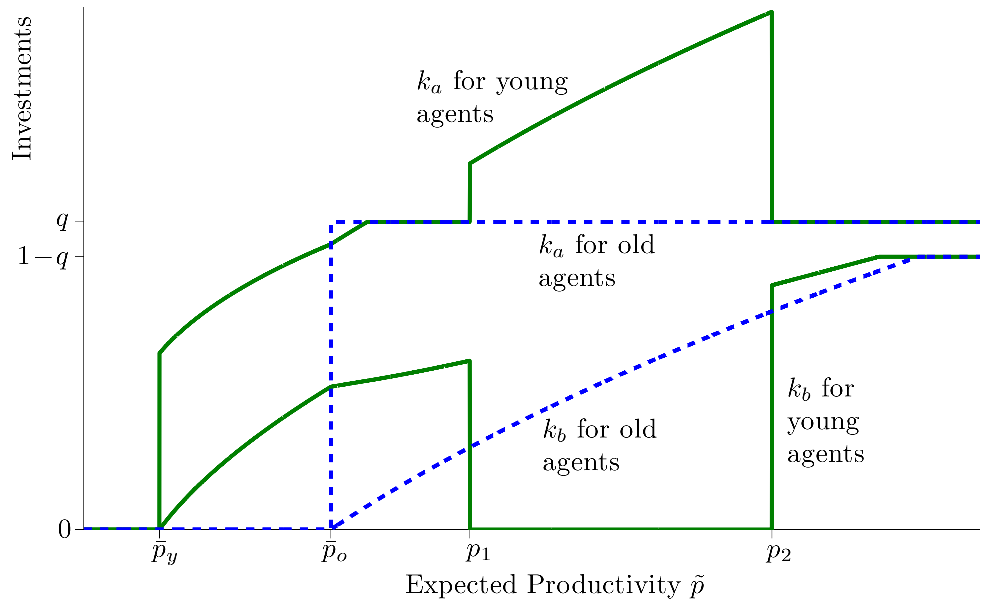

Fig. 3: Investment in k_a and k_b, for given agent's productivity and age.

when both young and old workers have the same productivity and receive the same type of contract.

4.5 Welfare

Limited liability affects social welfare through two channels. On the one hand, limited liability reduces the productivity of old agents (through distortions in infrastructure investment), which affects the signal value of young agents. On the other hand, limited liability distorts contractual and organizational choice for young agents given the signal value. Both channels operate through organizational choice, i.e., corporate infrastructure investments and contractual environments. The relation between the market equilibrium and the constrained efficient benchmark derived in Section 3 can be summarized as follows.

Corollary 1. *Compared to the constrained efficient allocation, in the market equilibrium with limited liability*

(i) fewer old agents and fewer young agents are employed,

(ii) corporate investments are distorted for old agents with intermediate types,

(iii) *flexible instead of rigid contracts are used for some young agents with intermediate types. Corporate investments for these agents are distorted toward B capital.*

That is, too few young workers are employed, implying that their productivity is not revealed. Moreover, the least productive among the employed workers receive rigid instead of flexible contracts. For these agents too little information is revealed compared to the constrained optimum, as a signal is generated only in state A. Therefore the laissez-faire outcome is characterized by too much idleness and too little talent discovery.

5 Discussion

5.1 Outcome Observability

In our model outcomes of tasks are publicly observable. Of course, in practice principals may attempt to obfuscate successes of their employees as to reduce the value of choosing the visible task. However, in many cases making output more or less visible involves a change in the worker's task assignment. For example, in order to obfuscate output, a principal may prevent a worker from attending meetings with clients or other firms, and instead assign him to other tasks. Hence, the choice between different degrees of output visibility can be formalized as a choice between different tasks. Our central trade off will remain as an agent will still be biased towards tasks that are inherently more visible and whose outcomes are costlier to conceal.

5.2 If the Agent Is Not an Expert

If the state of the world is observed by agents, principals, and third parties, contracts can specify a task contingent on the state. Therefore flexible contracts will not need to satisfy incentive compatibility for the agent. That is, in a flexible contract investments in B capital and monetary rewards for task b will not need to equalize the payoffs across states. Hence, under symmetric information, in case of a flexible contract investments k_a and k_b are chosen at the efficient ratio $k_a/k_b = q/(1-q)$ and joint surplus for a given productivity is greater than under asymmetric information. On the other hand, symmetry of information has no impact on the investment choice (and surplus) under a rigid contract. Hence, flexible contracts are used more frequently than in the case of asymmetric information. It follows that equilibrium on-the-job talent discovery and welfare are lower when the agent is not an expert (i.e., symmetric information about the state of the world) then when the agent is an expert (i.e., the agent has private information about the state of the world).

5.3 If the Routine Task b is Productive

If task b yields a positive return $r > 0$ with $R(A, \tilde{p}) > r > R(B, \tilde{p})$, the analysis derived above carries over qualitatively. A rigid contract will now be more costly but will still be chosen if the signal value is high enough relative to $r - R(b, \tilde{p})$. The main difference from the results above is that young agents with low expected productivity (the ones that are left unmatched when $r = 0$) are assigned to rigid contracts implementing the non-visible task b, which allows us to interpret our setup as a labor market with routine and complex occupations.

One industry that this type of equilibrium describes well could be academia, when teaching is interpreted as the non-visible task b, and research corresponds to the visible task a. The organizational and contractual choices for entry positions differ markedly across departments. Some departments favor organizational and contractual designs that primarily encourage task b (teaching) while relying on market incentives for task a (i.e. research output). Other departments appear to favor the exact opposite by encouraging research over teaching, using bonus payments for publications (but not for teaching), and providing large research budgets. The organizational structure in a third group seems to explicitly encourage both tasks. Our model suggest that, compared to the benchmark, in equilibrium young faculty may spend too much time teaching and not enough time doing research.

5.4 Firm Sizes

The assumption that firms consist of pairs of principals and agents can easily be extended to multiple agents per firm. If corporate investments can be tailored to each agent the problem is identical to the one studied above. If corporate investments apply to the whole firm, our results carry over qualitatively when states are drawn independently across agents, and when each agent's revenues depend exclusively on their own success or failure. In this case a firm's optimal investment depends on the menu of contracts used, and the organizational structure within an industry changes discontinuously in the employees' average productivity as above (see Appendix B). In addition, if firms are not constrained by technology in choosing the workforce composition, they will tend to hire homogeneous workers and choose the corresponding optimal organizational form (see, e.g., Gall, 2010, for a matching market model with heterogeneous agents and principals, and endogenous firm sizes).

5.5 Technological Change

Technological change may have an interesting effect on the dynamics of the labor market if different productivity types are affected differentially: i.e. if technological change is skill biased. A simple way to model this effect is to allow the top productivity $\overline{p}$ to increase. As a consequence, old agents' market values increase and the wage schedule for old agents becomes more convex.

This change increases the value of choosing the visible task for young agents, which, in turn, increases the desirability of rigid contracts and exacerbates under-investment in A capital. This effect is partially compensated for by an increase in young agents' market values as expected surplus increases due to technological change. That is, a shock that affects only some type of agents may generate substantial reorganization of all firms in this economy.

5.6 Dynamics

When moving from a two-period model to a multi-period model, the pattern described above largely carries over. As in Gibbons and Murphy (1992), the value of choosing action a decreases over the lifetime of an agent, reflecting the diminishing net present value of future earnings and the value of success as the agent grows older. In turn, this decline implies that the expected productivity of the marginal agent (who generates an expected joint surplus of 0) increases with an agent's age. Hence, the organizational choice described above functions as a screening mechanism that becomes increasingly demanding as agents grow older. In addition, the model predicts that within a given cohort, the use of rigid contracts and organizational heterogeneity decrease over time.

6 Conclusions

This paper has examined the organizational response of firms to the career concerns of agents. Our main assumption is that different tasks are differentially informative depending on the agents' talent. We show that firms that employ similar types of agents may optimally choose very different organizational forms, such as one that rewards idleness or one that rewards conspicuous activities. This is because tasks that generate public signals about the agent's productivity may impose a cost on the principal, and rewarding idleness discourages the agent from choosing such tasks. However, if the agent values generating public signals enough, the principal may find that discouraging the agent is too costly. The results are consistent with the observed heterogeneity in firms' provision of employee perks, reward schemes and management practices such as encouraging or discouraging overtime work.

In the labor market equilibrium, three different regimes of organizational choice can emerge: hidden gems (agents close to break-even productivity) receive flexible contracts that balance career concerns by rewarding idleness, but corporate investments are under-provided as a result of limited liability. This situation reflects a market failure because the surplus maximizing organization choice absent limited liability encourages talent discovery by mean of rigid contracts. High potentials (agents of intermediate productivities) receive rigid contracts encouraging visible activities and discouraging idleness. Proven talents (agents of high productivity) have weak career concerns and receive flexible contracts, where career concerns are balanced using monetary payments, and corporate infrastructure investments are efficient.

To derive the results in a tractable manner, we opted for simplicity rather than generality. For instance, principals are homogeneous. An extension could consider heterogeneity among employers, implying that the optimal task choice and organizational form will depend on the attributes of both principal and agent. This modification would entail specialization among principals, with some engaging in talent discovery and others in rewarding idleness. The distribution of principals would determine the degree of social learning and the distribution of types in the supply of older agents, generating interesting policy implications.

Finally, the model has implications for the analysis of job turnover and internal labor markets. Performing the visible task generates a public signal and thus an update of the agent's expected productivity. This signal also changes the organizational setup for the agent in the following period (i.e., when the agent changes jobs). Thus, a rigid contract can be interpreted as an 'up or out' work environment, where employees are either promoted or fired. A flexible contract allows for the possibility that an agent stays idle and remains in the organization in the following period. That is, turnover is lower in firms that invest more in B capital.

A Mathematical Appendix

Proof of Lemma 1

Denote by τ the prior belief over the distribution of $\underline{p}$ and $\overline{p}$, so that $\tilde{p} = \tau\overline{p} + (1-\tau)\underline{p}$. Then

$$p_S(\tilde{p}) = \frac{\tau\overline{p}}{\tau\overline{p} + (1-\tau)\underline{p}}\overline{p} + \left(1 - \frac{\tau\overline{p}}{\tau\overline{p} + (1-\tau)\underline{p}}\right)\underline{p}.$$

Using $\tilde{p} = \tau\overline{p} + (1-\tau)\underline{p}$ yields the expression in the lemma. An analogous argument yields $p_F(\tilde{p})$. If an agent chose task b or remained unmatched in the first period no new information is generated, therefore $p_I(\tilde{p}) = \tilde{p}$.

Proof of Proposition 1

Without limited liability the principal's choice of investments and contract type also maximizes expected joint surplus in a match. The expected joint surplus with a young agent given optimal investments is

$$E[\pi_j + u_i] = q[R(A,\tilde{p}) - c + s^*(\tilde{p})] + (q^2 + (1-q)^2)/2 - F \text{ with a flexible contract,}$$
$$E[\pi_j + u_i] = qR(A,\tilde{p}) + (1-q)R(B,\tilde{p}) - c + s^*(\tilde{p}) + 1/2 - F \text{ with rigid choice of } a,$$
$$E[\pi_j + u_i] = 1/2 - F \text{ with rigid choice of } b.$$

Bilateral comparison then yields the statements in the proposition, because $F \geq 1/2$ implies that rigid choice of b is dominated. For a match to be profitable $E[\pi_j + u_i] \geq F$, that is

$$qR(A,\tilde{p}) \geq F - (q^2 + (1-q)^2)/2 + q(c - s^*(\tilde{p})) \text{ with a flexible contract,}$$
$$qR(A,\tilde{p}) + (1-q)R(B,\tilde{p}) \geq c - s^*(\tilde{p}) + F - 1/2 \text{ with a rigid contract.}$$

Since both expressions increase in $\tilde{p}$ for $\tilde{p} \leq \bar{p}_o^*$ and a young agent with $\bar{p}_o^*$ must be employed, there is a break-even expected productivity $\bar{p}_y^* < \bar{p}_o^*$ such that all young agents with $\tilde{p} \geq \bar{p}_y^*$ are employed.

$\bar{p}_y^*$ is given by $R(A,\bar{p}_y^*) = c - s^*(\bar{p}_y^*) + F/q + 1 - q - 1/(2q)$ if $R(B,\bar{p}_y^*) \geq c - s^*(\bar{p}_y^*) - q$ and by $qR(A,\bar{p}_y^*) + (1-q)R(B,\bar{p}_y^*) = c - s^*(\bar{p}_y^*) + F - 1/2$ otherwise.

Proof of Proposition 2

Because $s^*(\tilde{p})$ attains a maximum at $\bar{p}_o^*$, rigid contracts will be used if $c - q < s^*(\bar{p}_o^*) + R(B,\bar{p}_o^*)$. Suppose this is the case. As both $s^*(\tilde{p})$ and $R(B,\tilde{p})$ increase in $\tilde{p}$ for $\tilde{p} < \bar{p}_o^*$, there is at most one $p_1 \in [\bar{p}_y^*, \bar{p}_o^*)$, such that $c - q - s^*(p_1) = R(B, p_1)$. Because $s^*(\tilde{p})$ approaches 0 as $\tilde{p}$ approaches $\overline{p}$, a flexible contract is used for $\tilde{p}$ in the neighborhood of $\overline{p}$. Hence, there is at least one $p_2 \in (\bar{p}_o^*, \overline{p})$, such that $c - q - s^*(p_2) = R(B, p_2)$. Because both $s^*(\tilde{p})$ and $R(B, \tilde{p})$ are linear functions of $\tilde{p}$, there is at most one such p_2. This implies that $c - q < s^*(\bar{p}_o^*) + R(B, \bar{p}_o^*)$ is also necessary for the use of rigid contracts. Since $u_o^*(p_S(\bar{p}_o^*)) = q(R(A, p_S(\bar{p}_o^*)) - c) + (q^2 + (1-q)^2) - F > 0$, $\bar{p}_o^* u_o^*(p_S(\bar{p}_o^*)) > 0$ and there are c, $q < c$ close enough to c, and $R(B, \tilde{p}) < 0$ close enough to 0 for $\tilde{p} \in [\underline{p}, \overline{p}]$, such that $c - q - R(B, \bar{p}_o^*) < q(R(A, p_S(\bar{p}_o^*)) - c) + (q^2 + (1-q)^2) - F$. For the last statement in the proposition note that $c - s^*(\tilde{p}) \leq (1-q)R(B, \tilde{p}) + 1/2$ (the condition that a rigid contract generates positive surplus) implies $c - s^*(\tilde{p}) \leq q + R(B, \tilde{p})$ (the condition that a rigid dominates a flexible contract) if $1/2 < q(1 - R(B, \tilde{p}))$.

Proof of Proposition 3

It suffices to compare the rigid choice of a to a flexible contract (the rigid choice of b yields a payoff of 0). Suppose $\underline{u} < 1 - c$ first, which implies $\underline{u} < 1 - q$. A flexible contract is more profitable if

$$(1-q)c + q^2/2 + (1-q)\underline{u} - \underline{u}^2/2 > (1-q)R(B, \tilde{p}_o) + c + \underline{u} - (c + \underline{u})^2/2.$$

After some rearranging this becomes

$$(c-q)^2/2 + (c-q)\underline{u} > (1-q)R(B, \tilde{p}_o),$$

where the LHS is strictly positive. Let now $1 - c < \underline{u} < 1 - q$. Then a flexible contract is more profitable if

$$(1-q)c + q^2/2 + (1-q)\underline{u} - \underline{u}^2/2 > (1-q)R(B, \tilde{p}_o) + 1/2.$$

This becomes

$$c - (1+q)/2 + \underline{u}(1 - \underline{u})/(2(1-q))) > R(B, \tilde{p}_o).$$

Since $1 - c < \underline{u} < 1 - q$ by assumption, the LHS is bounded below by $(c-q)/2 > 0$. Finally, in case $\underline{u} > 1 - q$ the condition is the same as in the benchmark case. This establishes the statement. The second statement follows from computing expected payoffs and the statements on investments have been derived in the text.

Proof of Proposition 4

Compute first the minimum productivity of an old agent required to generate positive surplus in firm. Note that positive surplus is only generated if task a is chosen with positive probability and by Proposition 3 a flexible contract dominates a rigid one. Using a flexible contract a principal j and an old agent i with expected productivity $\tilde{p}_o$ have positive expected surplus $\pi_j + u_i$ if

$$\pi_j = q(R(A, \tilde{p}_o) - c) + q^2/2 + (1-q)u_i - u_i^2/2 \geq F \text{ for } 0 \leq u_i \leq 1-q.$$

That is, the minimal $\tilde{p}_o$ of an an old agent such that joint surplus can be positive if that agent receives the outside option has to satisfy

$$\tilde{p}_o \geq \frac{c - \frac{q}{2} + F/q - \underline{R}(A)}{\overline{R}(A) - \underline{R}(A)}.$$

Note that $\bar{p}_o > \bar{p}_o^*$, so that by Assumption (A3) also $\bar{p}_o > \underline{p}$ for all $\pi \geq 0$. Hence, agents with high enough expected productivity to break even are scarce, since the measure of principals equals the one of all agents. Therefore in any labor market equilibrium each principal obtains payoff $\pi_j = 0$. Since $\pi_j = 0$ investments in a flexible contract are efficient if $u_i \geq 1 - q$, that is,

$$q(R(A, \tilde{p}_o) - c) + (q^2 + (1-q)^2)/2 - F \geq 1 - q.$$

Solving for $\tilde{p}_o$ yields

$$\hat{p}_o = \frac{c - q + F/q - \underline{R}(A) + \frac{1}{2q}}{\overline{R}(A) - \underline{R}(A)} > \bar{p}_o. \tag{13}$$

This allows computation of old agents' equilibrium payoffs $u_o(\tilde{p}_o)$ as a function of their expected productivity $\tilde{p}_o$ as given by expression (7) in the proposition.

Proof of Lemma 2

Parts (i) and (ii) of the lemma have been discussed in the benchmark case. Regarding part (iii), differentiating $s(\tilde{p})$ yields

$$\begin{aligned}\frac{\partial s(\tilde{p})}{\partial \tilde{p}} =& u_o(p_S(\tilde{p})) - u_o(p_F(\tilde{p})) + \tilde{p}\frac{\partial u_o(p_S(\tilde{p}))}{\partial p_S}\frac{\partial p_S(\tilde{p})}{\partial \tilde{p}} \\ &+ (1-\tilde{p})\frac{\partial u_o(p_F(\tilde{p}))}{\partial p_F}\frac{\partial p_F(\tilde{p})}{\partial \tilde{p}} - \frac{\partial u_o(\tilde{p})}{\partial \tilde{p}}.\end{aligned} \tag{14}$$

Since part (iii) requires $\tilde{p}$ to satisfy $\bar{p}_o < p_F(\tilde{p}) < \hat{p}_o$, necessarily $u_o(p^F(\tilde{p})) > 0$. Recalling that $p_F(\tilde{p}) = \frac{\tilde{p}(1-\underline{p}-\overline{p})+\underline{p}\overline{p}}{1-\tilde{p}}$ and using the definition of $\hat{p}_o$ in (13) it is easily verified that $p_F(\tilde{p}) > \bar{p}_o$ implies that $\tilde{p} > \hat{p}_o$. Therefore $u_o(\tilde{p}) > 1-q$ by the definition of $\hat{p}_o$, and $u_o(p^F(\tilde{p})) > 0$ as argued above, so that $\frac{\partial u_o(p_S(\tilde{p}))}{\partial p_S} = \frac{\partial u_o(\tilde{p})}{\partial p} > \frac{\partial u_o(p_F(\tilde{p}))}{\partial p_F}$ and the derivative (14) is positive.

Proof of Lemma 3

By assumption $\underline{u} \geq s(\tilde{p}) - c$, and the participation constraint binds for both types of contracts. We need to distinguish several cases.

Suppose $\underline{u} < s(\tilde{p}) - c + q$ first. Then $w_a = 0$ in both contracts and a rigid contract is preferred to a flexible contract if

$$-\frac{\underline{u}^2}{2} < (1-q)R(B,\tilde{p}) \text{ if } \underline{u} \leq 1-q$$
$$\frac{1-q}{2} - \underline{u} < R(B,\tilde{p}) \text{ if } \underline{u} > 1-q.$$

That is, a flexible contract is preferable if $\underline{u} < s(\tilde{p}) - c + q$ and

$$\underline{u} < \hat{u}(\tilde{p}) =: \begin{cases} (1-q)/2 - R(B,\tilde{p}) & \text{if } -2R(B,\tilde{p}) \geq 1-q \\ \sqrt{2(1-q)(-R(B,\tilde{p})} & \text{otherwise.} \end{cases} \tag{15}$$

Turn now to the case $s(\tilde{p}) - c + q \leq \underline{u} \leq s(\tilde{p}) + 1 - c$. Surplus is higher under a flexible than under a rigid contract if

$$q(s(\tilde{p}) - c) + \frac{q^2}{2} - \underline{u} + (1-q)k_b - \frac{k_b^2}{2} > (1-q)R(B,\tilde{p}) - \frac{(\underline{u} - s(\tilde{p}) + c)^2}{2}.$$

Solving for $s(\tilde{p})$ this yields a quadratic equation. Its determinant is positive if, and only if, $\underline{u} \geq \hat{u}(\tilde{p})$; otherwise the condition that a flexible contract is preferable always holds. Supposing $\underline{u} \geq \hat{u}(\tilde{p})$ the condition becomes

$$s(\tilde{p}) < \hat{s}(\underline{u}) := \underline{u} + c - q - \begin{cases} \sqrt{2(1-q)(\underline{u} + R(B,\tilde{p}) - (1-q)/2)} & \text{if } \underline{u} \geq 1-q \\ \sqrt{(\underline{u}^2 + 2(1-q)R(B,\tilde{p}))} & \text{otherwise.} \end{cases} \tag{16}$$

This defines a function $\hat{s}(\underline{u})$ for $\underline{u} \geq \hat{u}(\tilde{p})$ and $\hat{s}(\underline{u}) + q - c \leq \underline{u} \leq \hat{s}(\underline{u}) + 1 - c$. Since $\hat{s}(\underline{u}) \leq \underline{u} + c - q$ holds for the expression above, only the upper bound has a bite and becomes

$$(1-q)^2 - 2(1-q)R(B,\tilde{p}) \geq \begin{cases} 2(1-q)(\underline{u} - (1-q)/2) & \text{if } \underline{u} \geq 1-q \\ \underline{u}^2 & \text{otherwise.} \end{cases}$$

Because $(1-q)^2 - 2(1-q)R(B,\tilde{p}) > (1-q)^2$, the condition $\hat{s}(\underline{u}) + q - c \leq \underline{u} \leq \hat{s}(\underline{u}) + 1 - c$ holds if and only if $\hat{u} \leq \underline{u} \leq 1 - q - R(B,\tilde{p})$. Differentiating yields that $\hat{s}(\underline{u})$ is strictly decreasing on this interval.

Finally, let $\underline{u} > s(\tilde{p}) + 1 - c$. A flexible contract is now profitable if

$$q(s(\tilde{p}) - c) + \frac{q^2}{2} + (1-q)k_b - \frac{k_b^2}{2} > (1-q)R(B,\tilde{p}) - c + s(\tilde{p}) + 1/2.$$

That is,

$$s(\tilde{p}) < c - R(B,\tilde{p}) - \begin{cases} q & \text{if } \underline{u} \geq 1-q \\ ((1+q)/2 - \underline{u} + \underline{u}^2/(2(1-q))) & \text{otherwise.} \end{cases}$$

This defines $\hat{s}(\underline{u})$ for $\underline{u} > 1 - q - R(B,\tilde{p})$, because by assumption $\hat{s}(\underline{u}) - \underline{u} - c + 1 < 0$, which in turn becomes $1 - \underline{u} - R(B,\tilde{p}) < q$, as $(1-q)^2 - 2(1-q)R(B,\tilde{p}) < \underline{u}^2 < (1-q)^2$ yields a contradiction. That is,

$$\hat{s}(\underline{u}) = c - q - R(B,\tilde{p}) > 0 \tag{17}$$

for $\underline{u} > 2(1 - q - R(B,\tilde{p}))$.

Surplus efficiency follows directly from the characteristics of the optimal contracts (10) and (11). This establishes the proposition.

Proof of Lemma 4

Using $\pi = 0$, (10), and (9), the equilibrium payoff $u_y(\tilde{p})$ of a young agent with expected productivity $\tilde{p}$ under a flexible contract is given by

$$u_y(\tilde{p}) = \begin{cases} \sqrt{qR(A,\tilde{p}) - F - (c - s(\tilde{p}))^2/4} - (c - s(\tilde{p}))/2 & \text{if } u_y(\tilde{p}) < 1 - q, q + s(\tilde{p}) - c \\ \sqrt{2q(R(A,\tilde{p}) + s(\tilde{p}) - c + q) - 2F} - q & \text{if } q + s(\tilde{p}) - c < u_y(\tilde{p}) < 1 - q \\ \sqrt{2[(1-q)(1-q+c-s(\tilde{p})) + qR(A,\tilde{p}) - F]} - 1 + s(\tilde{p}) - c + q & \text{if } 1 - q < u_y(\tilde{p}) < q + s(\tilde{p}) - c \\ q(R(A,\tilde{p}) - c + s(\tilde{p}) + q/2) + (1-q)^2/2 - F & \text{if } u_y(\tilde{p}) > 1 - q, q + s(\tilde{p}) - c. \end{cases}$$

Under a rigid contract,

$$u_y(\tilde{p}) = \begin{cases} \sqrt{2(qR(A,\tilde{p}) + (1-q)R(B,\tilde{p}) - F)} - c + s(\tilde{p})) & \text{if } E[R(s,\tilde{p})] < 1/2 \\ qR(A,\tilde{p}) + (1-q)R(B,\tilde{p}) - c + s(\tilde{p}) + 1/2 - F & \text{if } E[R(s,\tilde{p})] \geq 1/2. \end{cases}$$

Note that lifetime utility for an agent is thus given by $u_y(\tilde{p}) + u_o(\tilde{p}_o)$. Establish first that $u_y(\tilde{p})$ strictly increases in $\tilde{p}$ when implementing task a at least some of the time. For this we need that $\frac{\partial s(\tilde{p})}{\partial \tilde{p}} > -[\overline{R}(A) - \underline{R}(A)]$, which is easily verified using the definitions of $s(\tilde{p})$ and $u_o(\tilde{p})$, which increases in $\tilde{p}$ as does $p_S(\tilde{p})$. In all cases the first derivative of $u_y(\tilde{p})$ with respect to $\tilde{p}$ is positive.

To check which of the above cases holds for $u_y(\bar{p}_y) = 0$, note first that $u_y(\bar{p}_y) < 1 - q$ so that $k_b = u_y(\bar{p}_y)$. Moreover, $s(\bar{p}_y) \leq c$. Suppose otherwise, then the agent's payoff in the firm is at least $s(\bar{p}_y) - c > 0$. But then there is $\tilde{p} < \bar{p}_y$ such that $s(\tilde{p}) - c > 0$. Hence, $u_y(\bar{p}_y) = 0$ and $s(\bar{p}_y) > c$ cannot both hold. Hence, either $u_y(\bar{p}_y) < 1 - q, q + s(\bar{p}_y) - c$ or $q + s(\bar{p}_y) - c < u_y(\bar{p}_y) < 1 - q$ must be the case. Setting $u_y(\bar{p}_y) = 0$ then yields

$$R(A, \bar{p}_y) = F/q + (c - s(\bar{p}_y))^2/(2q) \text{ if } s(\bar{p}_y) > c - q \text{ and}$$
$$R(A, \bar{p}_y) = c - s(\bar{p}_y) + F/q - q/2 \text{ otherwise.}$$

This immediately implies $\bar{p}_y > \bar{p}_o$ given by (6), since $R(A, \bar{p}_o) = c - q/2 + F/q$, with a strict inequality since $s(\bar{p}_o) > 0$. This also implies that $s(\bar{p}_y) = \bar{p}_y u_o(p_S(\bar{p}_y))$, which ensures that $s(\tilde{p})$ is increasing at $\bar{p}_y$. Using the definition of $s(\tilde{p})$ yields the cutoff productivity in terms of the primitives.

Proof of Proposition 5

The cutoff values $\bar{p}_o$ and $\bar{p}_y$ have been established before. A rigid contract is preferable for productivity $\tilde{p}$ if, and only if, $s(\tilde{p}) \geq \hat{s}(u_y(\tilde{p}))$. By lemma 4 the optimal contract for young agents with $\tilde{p} \geq \bar{p}_y$ in the neighborhood of $\bar{p}_y$ is flexible. Hence, there is $p_1 \in (\bar{p}_y, \overline{p}]$, such that flexible contracts are optimal for $p_y \leq \tilde{p} \leq p_1$. Clearly, $\lim_{\tilde{p} \to \overline{p}} s(\tilde{p}) = 0$, while $\hat{s}(u_y(\tilde{p})) > 0$ as defined in the proof of Lemma 3. Therefore there is $p_4 \in [\bar{p}_y, \overline{p})$, such that flexible contracts are optimal for $p_4 \leq \tilde{p} \leq \overline{p}$.

Next we derive a sufficient condition for existence of rigid contracts (i.e. $\bar{p}_y < p_1 < p_4 < \overline{p}$). To do so we focus on $\bar{p}_o$ where $s(\tilde{p})$ attains a maximum. A rigid contract is desirable for $\bar{p}_o$ if $u_y(\bar{p}_o) > \hat{u}(\bar{p}_o)$ and $s(\bar{p}_o) > \hat{s}(u_y(\bar{p}_o))$. Using the definition of $\hat{s}(u_y(\tilde{p}))$ in the proof of Lemma 3, a sufficient condition for the second is $s(\bar{p}_o) \geq u_y(\bar{p}_o) + c - q$. Because $u_o(\bar{p}_o) = 0$ and $k_a = q$ for the old agent, it follows that $u_y(\bar{p}_o) \geq s(\bar{p}_o) + q - c$ iff $s(\bar{p}_o) + q - c \geq \sqrt{2q(c-q)}$. Hence, for $c - q$ sufficiently small $s(\bar{p}_o) > \hat{s}(u_y(\bar{p}_o))$. Note that $s(\bar{p}_o) + q - c > \sqrt{2q(c-q)}$ implies $u_y(\bar{p}_o) > \sqrt{2q(c-q)}$.

$u_y(\bar{p}_o) > \hat{u}(\bar{p}_o)$ holds if

$$u_y(\bar{p}_o) > \begin{cases} (1-q)/2 - R(B,\bar{p}_o)/q & \text{if } -2R(B,\bar{p}_o) \geq 1-q \\ \sqrt{2(1-q)(-R(B,\bar{p}_o))} & \text{otherwise.} \end{cases} \tag{18}$$

Because $u_y(\bar{p}_o) > \sqrt{2q(c-q)}$, for any $c > q$ there is a function $R(B,\tilde{p})$ with $|R(B,\tilde{p})| < (1-q)/2$ small enough for all $\tilde{p}$ such that the above condition is satisfied.

That is, if effort cost c and expected revenue of task b, $R(B,\tilde{p})$ for all $\tilde{p}$ are sufficiently close to q and to 0, respectively, there is a productivity $\bar{p}_y < \bar{p}_o < \overline{p}$ such that a young agent with that productivity receives a rigid contract. If $\hat{s}(u_y(\tilde{p}))$ is convex this implies that $\hat{s}(\tilde{p})$ and $s(\tilde{p})$ intersect twice at most. Otherwise, there may be more intersection points.

For flexible contracts $k_b = \min\{1-q; u_y(\tilde{p})\}$. Therefore $0 < k_b \leq 1-q$ for $\tilde{p} > \bar{p}_y$. For rigid contracts $k_b = 0$. Rigid contracts are optimal only if $s(\tilde{p}) > \hat{s}(\tilde{p})$. This implies $u_y(\tilde{p}) + c - s(\tilde{p}) > q$ (see proof of Lemma 3). This means that $q < k_a \leq 1$ in rigid contracts. For $s(\tilde{p}) < \hat{s}(\tilde{p})$ a flexible contract is optimal, with $k_a = \min\{u_y(\tilde{p}) + c - s(\tilde{p}); q\}$. Since $u_y(\tilde{p}) + c - s(\tilde{p}) > q$ for $p_1 < \tilde{p} < p_2$ and $\frac{\partial u_y(\tilde{p})}{\partial \tilde{p}} > \frac{\partial s(\tilde{p})}{\partial \tilde{p}}$ for $q > 1/2$, $u_y(\tilde{p}) + c - s(\tilde{p}) > q$ and $k_a = q$ for $\tilde{p} > p_2$.

Finally, a sufficient condition for rigid contracts not to occur is $s(\tilde{p}) < c - q - R(B,\tilde{p})$ for all $[\bar{p}_o, \overline{p}]$. This is implied by $s(\bar{p}_o) < c - q - R(B,\bar{p}_o)$.

Details for Corollary 1

For the statements on employment, note that $\bar{p}_o > \bar{p}_o^*$ by Proposition 4. To show that also $\bar{p}_y > \bar{p}_y^*$ requires a bit of work. Recall from the proof of Proposition 1 that

$$R(A,\bar{p}_y^*) + s^*(\bar{p}_y^*) \leq c + \frac{F}{q} + 1 - q - \frac{1}{2q}.$$

The weak inequality is due to assuming that a flexible contract is used for $\bar{p}_y^*$, which may not be optimal (e.g., when $q \geq 1/2$. On the other hand, recall from the proof of Lemma 4 that

$$R(A,\bar{p}_y) + s(\bar{p}_y) \geq c + \frac{F}{q} - \frac{q}{2}.$$

The inequality is strict if $q > c - s(\bar{p}_y)$. Moreover, $s^*(p) > s(p)$ for $p < \bar{p}_o$, since no limited liability constraints reduces old agents' payoff for $s^*(p)$, $p < \bar{p}_o$. Because $R(A,p)$ is strictly increasing in p,

$$c + \frac{F}{q} + 1 - q - \frac{1}{2q} < c + \frac{F}{q} - \frac{q}{2}$$

implies that indeed $\bar{p}_y^* < \bar{p}_y$.

Distortions in corporate investment follow from Proposition 3 for old agents and from Lemma 3 for young agents. Distortions in contractual choice for young agents for $q \geq 1/2$ follow from Propositions 2 and 5.

B Large, Heterogeneous Firms: Benchmark Case

Suppose that a firm hires two workers with expected productivities $\tilde{p}_1$ and $\tilde{p}_2$ and signal values s_1 and s_2. This setup encompasses arrangements where a young and an old agent, with $s_1 > 0$ and $s_2 = 0$, form a team. To illustrate the mechanics let us focus on the benchmark case without limited liability. There are three cases: the firm uses (i) only rigid contracts, (ii) only flexible contracts, or (iii) different contracts.

Case (i). Incentive compatibility and individual rationality require

$$w_a^i + s_i - c + k_a \geq w_b^i + k_b \text{ and } w_a^i + s_i - c + k_a \geq \underline{u}_i.$$

The principal's payoff is

$$\pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2)) + (1-q)(R(B, \tilde{p}_1) + R(B, \tilde{p}_2)) - w_a^1 - w_a^2 - (k_a^2 + k_b^2)/2 - F.$$

Hence, $k_b = 0$ and $w_b^i = 0$, and $w_a^i = \underline{u}_i - s_i + c - k_a$. This in turn means that joint profit is maximized if $k_a = 2$. Joint surplus is thus

$$\underline{u}_1 + \underline{u}_2 + \pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2)) + (1-q)(R(B, \tilde{p}_1) + R(B, \tilde{p}_2)) - 2c + s_1 + s_2 + 1 - F.$$

Case (ii). Incentive compatibility and individual rationality require

$$w_a^i + s_i - c + k_a = w_b^i + k_b \text{ and } w_a^i + s_i - c + k_a \geq \underline{u}_i.$$

The principal's payoff is

$$\pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2) - w_a^1 - w_a^2) - (1-q)(w_b^1 + w_b^2) - (k_a^2 + k_b^2)/2 - F.$$

Hence, $w_a^i = \underline{u}_i - s_i + c - k_a$ and $w_b^i = \underline{u}_i - k_b$. This in turn means that joint profit is maximized if $k_a = 2q$ and $k_b = 2(1-q)$. Joint surplus is thus

$$\underline{u}_1 + \underline{u}_2 + \pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2) - 2c + s_1 + s_2) + 2q^2 + 2(1-q)^2 - F.$$

Case (iii). Suppose that worker 1 receives a rigid contract and worker 2 are flexible one (implying that $s_1 > s_2$). Then incentive compatibility and individual rationality require

$$w_a^1 + s_1 - c + k_a \geq w_b^1 + k_b \text{ and } w_a^2 + s_2 - c + k_a = w_b^2 + k_b \text{ and } w_a^i + s_i - c + k_a \geq \underline{u}_i.$$

The principal's payoff is

$$\pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2) - w_a^2) + (1-q)(R(B, \tilde{p}_1) - w_b^2) - w_a^1 - (k_a^2 + k_b^2)/2 - F.$$

Therefore $w_a^i = \underline{u}_i - s_i + c - k_a$ and $w_b^i \leq \underline{u}_i - k_b$. Using this on the firm's profit yields optimal investments $k_a = 1 + q$ and $k_b = 1 - q$. Joint surplus is thus

$$\pi = q(R(A, \tilde{p}_1) + R(A, \tilde{p}_2) - c + s_2) + (1-q)R(B, \tilde{p}_1) + s_1 - c - \underline{u}_1 - \underline{u}_2 + 1 + q^2 - F.$$

That is, depending on workers' types one of three contracting regimes will be chosen, differing significantly and discretely in the corporate investment composition. If, for instance, and old ($s_2 = 0$) and a young ($s_1 > 0$) agent are matched, a mixed regime will dominate a pure rigid regime if

$$c - q - 1 > R(B, \tilde{p}_2) = \underline{R} + \tilde{p}_2(\overline{R} - \underline{R}).$$

The mixed regime will dominate a pure flexible regime if

$$c - q - (2q - 1) < R(B, \tilde{p}_1) + s_1.$$

Hence, if an intermediate old agent teams up with a similarly productive, high signal value young agent, the old agent will have more flexibility in the task chosen and a higher part of the salary will be independent of the task. Corporate infrastructure investments will be geared towards A capital, with $k_a > k_b > 0$.

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