The Dynamics of Exploiting Overconfident Workers*

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Abstract

We develop a model of a long-term employment relationship in which a firm may have an incentive to reassign a worker who has proved himself to be good at his current job – even if he is not well-suited for the new position. This occurs because, once a worker's talent becomes evident, the firm can no longer exploit his overconfidence, which reduces the profitability of his current employment. This insight provides a new microfoundation for the (intentional) mismatch between employees and their tasks that is commonly referred to as the "Peter Principle."

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1 Introduction

Humans systematically overestimate their abilities. Many think they are better drivers than the average, more intelligent, or better at predicting political outcomes (Myers, 2010; Bondt and Thaler, 1995; see Meikle et al., 2016 or Santos-Pinto and de la Rosa, 2020 for overviews). Recent evidence points towards the prevalence of such "overconfidence" also in the workplace – among managers (Malmendier and Tate, 2005; Malmendier and Tate, 2015; Huffman et al., 2022) as well as non-executives (Hoffman and Burks, 2020).

We are just beginning to understand the extent and persistence of workers' overconfidence, and how it may affect the structure of long-term employment relationships. Whereas some studies argue that it can be cheaper for firms to hire overconfident workers who overestimate their chances of achieving a successful outcome (Santos-Pinto, 2008; de la Rosa, 2011; Sautmann, 2013), their focus is on one-shot interactions. But the relevance of such "exploitation contracts" relies on their ongoing use over an extended period of time. If workers learn and update their assessments (as studies such as Grossman and Owens, 2012 or Yaouanq and Schwardmann, 2022 indicate), their exploitation may quickly become infeasible.

In this paper, we show that a firm's exploitation of a worker's overconfidence about his talent can *intensify* over time, even though he incorporates informative signals and updates beliefs using Bayes' rule. This implies that the firm's expected profits can rise as bad signals about the worker's talent accumulate and firm and worker become increasingly pessimistic.We apply these results to a firm's job assignment and promotion strategies and demonstrate that it can be optimal to keep workers in a role *only as long as they have not* proven to excel at it. Once they demonstrate their competence, the firm might reassign them to different tasks with unrelated requirements. We suggest that these reassignments resemble promotions, mainly because they come with large bonuses or salary increases. The rationale for such a promotion policy is that a success reduces the uncertainty about the worker's ability, and a subsequent promotion re-instates belief divergence, thereby creating new opportunities for exploitation.

Thereby, we provide a microfoundation for the so-called *Peter Principle*, according to which firms prioritize current performance in promotion decisions, often overlooking those with the greatest potential for success in future roles (Benson et al., 2019). In contrast to the prevailing alternative theoretical explanations, our approach does not rely on (parts of) the worker's performance being unverifiable, and is thus able to rationalize recent evidence by Benson et al., 2019 for the existence of the Peter Principle among highly confident sales agents whose performance can easily be verified.

Our results are derived in a continuous-time setting, where a risk-neutral principal can either hire a risk-neutral agent to work on a task or exercise her outside option. The agent's value to the principal in this task contains a deterministic part and his stochastic talent, which is either high or low. If talent is high, the agent generates a verifiable extra profit to the principal with some probability at each instant in time. If talent is low, the extra profit is never generated. The agent's talent is initially uncertain, and both players adjust their beliefs using Bayes' rule:[1] Once the extra profit materializes for the first time, beliefs of the agent being talented jump to 1. Otherwise, beliefs go down. The agent is *overconfident* about his talent, i.e., his starting belief of being talented exceeds the principal's. We analyze the compensation contract offered to the agent, as well as the expected compensation dynamics and the principal's decision regarding when to hire the agent or exercise her outside option. We will argue that exercising the outside option should not merely be seen as a termination of the relationship. Instead, it could represent the principal's value in assigning the agent a new task. Since this reassignment includes a substantial bonus, it may be perceived as a promotion. We derive the following results.

First, as long as the agent is (strictly) overconfident, the **optimal compensation contract** offers no payment unless there is a success. From the agent's perspective, this wage (in expectation) compensates him for his outside option. However, from the perspective of the principal (who holds a

[1] Evidence for employer learning is provided by Lange (2007) or Kahn and Lange (2014).

lower belief about the agent's talent), the expected value of the wage is less than the agent's outside option. As a result, this setup constitutes an *exploitation contract*. Additionally, the more overconfident the agent is, the less the principal expects to pay. Once the agent reveals high talent through an initial success, it becomes optimal to provide a fixed wage that covers his outside option.

Second, the **expected compensation dynamics** are driven by the evolution of the ratio between the principal's and the agent's beliefs. As time passes without success, both beliefs decline and approach zero, causing the wage paid after the first success to increase. However, the principal's belief decreases more rapidly than the agent's, leading to a reduction in the agent's expected compensation from the principal's perspective and *increasing the level of exploitation*, even as the agent becomes more pessimistic. Meanwhile, the total profits from employing the agent also contain the extra profit in case he is talented, and this component decreases over time if no success occurs. The balance between the (expected) profits from exploiting the agent and the extra profit if the agent is talented depends on the size of this extra profit and the initial belief gap, reflecting the agent's overconfidence.

This determines our third set of results, the principal's **hiring and firing/job assignment policy**. There, the principal faces a trade-off between getting a risky payoff associated with experimentation that she obtains (in addition to some certain payoff) when hiring the agent, and consuming her outside option when not hiring the agent. As previously stated, the latter can either be interpreted as firing the agent or reassigning him to a different job. In the following, we will first use the terminology related to firing before examining the reassignment option more closely. In our setting, the value of experimentation stems not only from the possibility that the agent is talented, but also from the gains the principal can make by exploiting the agent's overconfidence. If the expected value of experimentation is relatively low – due to a small (expected) value of the agent's talent and a small difference in beliefs – the principal never hires the agent. Conversely, if the expected value of experimentation is high – driven by a high talent potential or significant exploitation opportunities – the principal will always hire the agent.

When the extra profit is large but the initial belief gap is small, the principal will only hire the agent for the task if she has a sufficiently optimistic belief that the agent is talented. Here, exploitation opportunities are minimal, and hiring is based primarily on the agent's potential talent. In this case, the principal's value increases with her belief, and the agent is fired after a long enough string of failures. On the other hand, if the extra profit is small but the initial belief gap is large, the principal hires the agent only when she is *sufficiently pessimistic* about his talent. In this scenario, despite expecting the agent to have low talent, the principal benefits from exploiting the large belief difference. Here, the principal's value decreases as her belief increases, meaning her profits can *rise with the agent's failures*, and the agent is fired after a success.

Next, we consider the interpretation where, instead of terminating the agent's employment, the principal assigns the agent to a different role when exercising her outside option. For the case where the principal's profits increase with failures, such a reassignment can appear as a promotion since it includes a substantial bonus. Consequently, it might be optimal to promote the agent following a success in the initial role, even if the agent's abilities in the two positions are entirely unrelated. In general, the agent's overconfidence leads the principal to put less weight on the agent's inherent ability for the new job than would be warranted by productive efficiency. This result is further exacerbated if the agent is also overconfident in the second job. A success in the first job eliminates the principal's opportunities to exploit the agent there. Promoting him to the second job reintroduces uncertainty about the agent's talent, thereby creating new opportunities to exploit his overconfidence. Furthermore, a worker who is currently unsuccessful but is expected to be talented in the second job may not be promoted because his continued lack of success increases the firm's profits from exploiting him in his current role.

This mechanism encourages a policy where the agent who is promoted is not necessarily the best-suited for the position. Thereby, we provide a microfoundation for the Peter Principle which, according to Benson et al. (2019), implies that firms prioritize current performance in promotion decisions instead of promoting the candidates with the best potential for the new job. In contrast to the alternative explanations we are aware of, our approach can generate the Peter Principle even if the agent's performance is verifiable. Indeed, Benson et al. (2019) demonstrate that the promotion of sales workers is to a larger extent determined by their verifiable sales than would be justified by their fit for a managerial position. Moreover, this link between sales and promotion is especially strong for so-called "lone wolves" who are highly self-confident but whose fit for managerial positions is particularly poor because of a lack of willingness to collaborate with others.

After deriving these results, we discuss some implications of our model. First, since the agent is only paid after a success, our setting seems to predict substantial pay for performance. Indeed, there is evidence that performance-based pay is often observed in occupations where overconfidence is common – such as sales or management. Additionally, we argue that the high bonus could instead manifest itself in a high fixed wage that is continuously paid after an initial success. Second, we discuss the implications of the agent being risk averse instead of being protected by limited liability. We argue that, while the optimal compensation scheme then also contains some fixed wage to limit the agent's exposure to risk, a bonus conditional on success is still paid to exploit the agent's overconfidence. Finally, we consider Bertrand competition for the agent and demonstrate that the hiring decisions in this case are the same as in our main setting, where the principal has full bargaining power.

Related Literature

We contribute to the literature on incentive contracts with overconfident agents. DellaVigna and Malmendier (2004) and Heidhues and Kőszegi (2010) provide early work on how to design incentive contracts when consumers are overconfident, in this case about their future self control. They show that exploitation is optimal and feasible. In a static employment setting with a risk-neutral principal and a risk-averse agent, Santos-Pinto (2008) and de la Rosa (2011) demonstrate that implementing effort can be cheaper if the agent is overconfident about his ability. Moreover, exploitation contracts can emerge, in which an agent's overconfidence gives him a realized expected utility that is smaller than anticipated by himself. Although the mechanisms behind such "exploitation contracts" seem well understood, and laboratory (Larkin et al., 2012; Sautmann, 2013) as well as field evidence (see Otto, 2014; Humphery-Jenner et al., 2016, for executives) suggests that overconfident employees can indeed be exploited, the benefits for firms depend on whether these practices can be consistently applied over an extended period. Understanding how employees assess feedback is crucial, as learning and updating their assessments (such as in Yaouanq and Schwardmann, 2022) could make exploitation infeasible. We demonstrate that learning about the source of overconfidence can actually increase exploitation. Even with complete learning, firms can reintroduce uncertainty and overconfidence by promoting the agent. Existing dynamic models with overconfident agents either rely on environments of misspecified learning in which success has several determinants and the agent is overconfident about one of them (Heidhues et al., 2018; Heidhues et al., 2021; Hestermann and Yaouanq, 2021; Murooka and Yamamoto, 2021), or assume that the agent assigns probability 1 to one state of the world and therefore does not update when receiving new information (Englmaier et al., 2020).

We also relate to the theoretical literature on the "Peter Principle," according to which firms prioritize current performance in promotion decisions over potential ability in the new job. For example, firms may use promotions instead of monetary bonuses to incentivize workers because the latter are more prone to influence activities by workers (Milgrom and Roberts, 1988; Fairburn and Malcomson (2001)). These models rely on an effort dimension that is *not* objectively measurable and can therefore be misreported by supervisors. By the same token, in Lazear (2004), firms do observe but a noisy signal of an agent's talent. In expectation, a high observation will correspond to a high noise term. Firms anticipate this sub-optimal allocation that is due to mean reversion but, given the information they have access to, they cannot avoid the Peter principle. Although these – and other – theories are able to rationalize the incentive roles of promotions, they are insufficient to explain the observations made by Benson et al. (2019), which are based on an easily verifiable task and highly confident individuals. Instead, we argue that firms might *intentionally* promote revealed high performers even though they know this is inefficient, doing so as a means of optimally exploiting overconfident workers.

2 Model

A principal ("she") and an agent ("he") interact in continuous time over an infinite horizon. Both parties discount future payoffs at the rate of $r > 0$. At each instant $t \in \mathbb{R}_+$, the principal can either hire the agent or exercise her outside option. Exercising her outside option in $[t, t + dt)$ comes with a profit flow of $\bar{\pi} dt$, where $\bar{\pi} \in [0, 1]$. If the agent is hired at instant t, he incurs an (opportunity) cost of $cdt > 0$. This opportunity cost may not only capture the utility of working for a different firm (or not working at all), but also the cost of exerting contractible effort. The agent's time-invariant talent $\theta \in \{0, 1\}$ determines the principal's profit flow over those time intervals in which the agent is hired. We use continuous time because it allows us to explicitly characterize value functions. Our results below on how the principal's cost of hiring the agent evolve over time would also apply in discrete time.

Indeed, if the agent is hired over a time interval $[t, t+dt)$, the principal's profit flow over that period is given by $1 \cdot dt$; with probability $\theta a dt$, for some $a > 0$, the principal additionally receives the lump sum $\eta > 0$. The parameter a governs the speed with which a talented agent (i.e., one with $\theta = 1$) produces a breakthrough success (of value η to the principal), and therefore the speed at which the talented agent reveals his type. The principal initially believes that the agent is talented with probability $p_0^P \in (0, 1)$; the agent initially believes that he is talented with probability $p_0^A \in [p_0^P, 1)$. We thus assume that $p_0^A \geq p_0^P$, i.e., the agent is *over-confident.* Both players update their beliefs according to Bayes' rule: as soon as an extra profit has been observed, both players' beliefs jump to 1, and stay there. If no extra profit has arrived by period t, party i's belief can be written as

$$p_t^i = \frac{p_0^i e^{-a\int_0^t \chi_\tau \, d\tau}}{p_0^i e^{-a\int_0^t \chi_\tau \, d\tau} + 1 - p_0^i},$$

where we write $\chi_\tau = 1$ ($\chi_\tau = 0$) if the agent is (not) hired at instant τ. Let us write beliefs in the form of the odds ratio; in particular, we write $x_t^A = p_t^A/(1-p_t^A) = x_0^A e^{-a\int_0^t \chi_\tau \, d\tau}$, and $x_t^P = p_t^P/(1-p_t^P) = x_0^P e^{-a\int_0^t \chi_\tau \, d\tau}$. Thus,

$$\frac{x_t^P}{x_t^A} = \Psi \in (0, 1]$$

is constant over time. Ψ is a parameter of the problem, which measures how the players' initial beliefs relate to each other. It is an inverse measure of the agent's over-confidence, with $\Psi = 1$ corresponding to the case of common priors. In the following, we shall refer to x_t^A (Ψx_t^A) as the agent's (principal's) *belief* at instant t. This formulation simplifies our exposition in two ways: first, it allows us to focus on just one variable, x_t^A, to track the evolution of beliefs (instead of p_t^P and p_t^A); second, the agent's overconfidence can be represented by the constant Ψ. However, from time to time we will still refer to the untransformed beliefs p_t^P and p_t^A when it helps to better convey intuition.

Note that Ψ has an additional interpretation. It equals $\lim_{t\to\infty} p_t^P/p_t^A$ conditional on no success being observed; thus, although each of the beliefs approaches zero in that case, the limit of the ratio is strictly positive. This interpretation will become important when we discuss the dynamics of the costs of hiring the agent.

Contracts, Information, and Equilibrium The principal can make non-negative transfers to the agent, who is protected by limited liability.

She does not have any long-term commitment power; i.e., she is restricted to offering spot contracts. We furthermore restrict our attention to *Markov spot contracts.*These specify the agent's instantaneous wage payment as a function of the principal's current profit, which is assumed to be verifiable, and the players' current beliefs. The verifiability of profits allows the principal to let wages depend on the realization of the extra payment η. Thus, let b_t denote the lump-sum payment the agent receives in case he produces the payment η, while w_t is his flow payment at instant t in the absence of a success.

The agent's belief is common knowledge. We do not need to specify whether the agent is aware of the principal's belief as long as the agent's belief, and his overconfidence, are not affected by the principal's contract offer. For example, both might agree to disagree. We solve for a perfect Bayesian equilibrium (PBE) that maximizes the principal's profits (given her beliefs).

Recall that χ_t is an indicator that is equal to 1 if the agent is employed at instant t, and 0 otherwise. Thus, the principal's objective is to maximize

$$\int_0^\infty re^{-rt}\left\{\chi_t\left[1+\mathbb{E}_0^P\left[\theta a\left(\eta-b_t\right)\right]-w_t\right]+\left(1-\chi_t\right)\bar{\pi}\right\}dt$$

subject to the agent's participation constraint,

$$\int_t^\infty re^{-r(\tau-t)}\left\{\chi_\tau\left[\mathbb{E}_\tau^A\left[\theta ab_\tau\right]+w_\tau\right]+\left(1-\chi_\tau\right)c\right\}d\tau\geq 0 \text{ for all } t\text{, and all histories}$$

and the limited-liability constraints,

$$b_t\geq 0 \text{ for all } t\text{, and all histories,}$$

and

$$w_t\geq 0 \text{ for all } t\text{, and all histories,}$$

where we write $\mathbb{E}_t^P$ ($\mathbb{E}_t^A$) for the principal's (agent's) expectation based on the information available up to time t.

At any instant, the principal's strategy consists of two components. First, whether to hire the agent or to exercise her outside option. Then, if she decides to hire the agent, how to structure his compensation. As we will discuss in Section 4 below, exercising the outside option $\bar{\pi}$ can either mean terminating the relationship or, if the principal has this option available, reassigning the agent to a new task. In the following sections, we will break down these components step by step.

3 Results

First, derive the optimal compensation structure given the agent is hired by the principal. It is possible to offer a spot contract that pays the agent his opportunity cost c, independently of beliefs about θ. The agent would be willing to accept such an offer, which would allow the principal to extract the whole rent generated by the agent's employment. However, with $\Psi < 1$, i.e., with $p_0^A > p_0^P$, it is optimal for the principal to exploit the agent's overconfidence and only to pay him conditionally on his producing the extra profit η. The reason is that the agent's belief of being talented and thus of receiving the payment is higher than the principal's, so that both players gain by letting pay depend on "performance", i.e., the arrival of the extra profit.[2] The risk-neutral agent is willing to accept any contract that at least covers his opportunity cost in expectation, $c/ap_t^A = \left(1 + x_t^A\right) c/ax_t^A$. In a profit-maximizing equilibrium it is clearly not optimal to leave the agent a rent. These considerations lead to the following:

Lemma 1 *Provided the principal employs the agent, the following compensation structure is optimal. For all x_t^A, the agent's participation constraint binds for all t and all histories, and $w_t = 0$. After a success at time t, the principal pays the agent a lump-sum amount of $b_t = \left(1 + x_t^A\right) c/ax_t^A$.*

[2] On account of the belief differences, performance pay allows the players to engage in *side bets* in the sense of Cremer and McLean (1988). Indeed, an overconfident agent's estimate of his chance of producing a bonus payment is higher than the principal's estimate. As they disagree on the probability of the bonus, there are bets on this event that both would consider strictly advantageous for themselves.

Note that this structure is (strictly) optimal (for $\Psi < 1$) as long as there has been no success. Once the extra profit has been realized and both players' beliefs jump to 1, this contract generates the same profits as one in which the principal just pays a flow of c irrespectively of whether η materializes or not. The following remark is an immediate consequence of Lemma 1.

Remark 1 *The cost of hiring the agent from the principal's perspective, which in the following we refer to as the* principal-expected *cost, amounts to*

$$\frac{p_t^P}{p_t^A}c = a\Psi\frac{x_t^A}{1+\Psi x_t^A}b_t = \frac{1+x_t^A}{1+\Psi x_t^A}\Psi c.$$

Note that the principal-expected cost of hiring the agent is smaller than c and, for a given x_t^A, is increasing in Ψ.[3] Thus, the greater the agent's overconfidence (and thus the lower Ψ), the lower the amount the principal expects to pay the agent for his employment.

3.1 The Cost of Learning

Now, we explore how the agent's expected compensation evolves over time. Clearly, after a success, beliefs jump to 1 and stay there forever thereafter, which implies that expected hiring costs then also become time-invariant. As long as no success has been realized, though, these expected costs decrease as time passes.

Lemma 2 *b_t is decreasing in x_t^A and hence increasing in time t if there is no success.*
The principal-expected cost of hiring the agent,

$$\frac{p_t^P}{p_t^A}c = a\Psi\frac{x_t^A}{1+\Psi x_t^A}b_t = \frac{1+x_t^A}{1+\Psi x_t^A}\Psi c,$$

[3] The optimality of such compensation structures is widely known in settings with non-common priors, see Eliaz and Spiegler (2006), or Grubb (2015) for an overview. See also Santos-Pinto (2008) for a risk-averse agent.

is increasing in x_t^A*; it tends to* Ψc *as* $x^A \to 0$*, and to* c *as* $x^A \to \infty$*. It is a martingale on the principal's information filtration; in case of a success, it jumps up to* c*, and is decreasing in time* t *if there is no success.*

Without any success, both the principal's and the agent's beliefs go down and eventually approach zero. Because $p_t^P < p_t^A$, though, Bayes' rule indicates that the *relative* reduction of beliefs conditional on no success occurring,

$$\frac{dp_t^i}{p_t^i} = -a(1 - p_t^i)dt,$$

is more pronounced for the principal than for the agent. Indeed, on account of the agent's overconfidence, the principal's posterior goes down faster than the agent's. This allows the principal to keep exploiting the agent by promising to offer him an increasingly higher payment for success, which takes place with an ever smaller probability. Hence, as failures accumulate, the agent continues to accept the contract and is exploited every time as his expected compensation decreases.[4]

This implies that learning does not necessarily benefit the agent. If no success is observed and negative signals accumulate, the agent's (principal-)expected compensation goes down. Therefore, even if agents update their beliefs about the underlying source of their overconfidence using Bayes' rule (for which there is evidence, see Yaouanq and Schwardmann, 2022), their exploitation need not vanish in the long run – to the contrary, it may even exacerbate. Note that this result does not rely on time being continuous but also holds if time is discrete.

We assume an infinite time horizon; calendar time thus plays no role *per se*—it is only the space in which the relevant variables, in particular the belief x_t, evolve. In the following, we shall therefore suppress calendar time in the subscript of the variables (i.e., write e.g. x^A instead of x_t^A) whenever convenient.

[4] We are indebted to an anonymous referee for suggesting this intuition.

3.2 The Optimal Hiring and Firing Decision

Given the optimal compensation policy, the principal's strategy boils down to choosing whether to hire the agent at each instant as a function of the previous history, or to exercise her outside option.[5] The latter can either mean terminating the relationship or reassigning the agent to a different ask (which may empirically look like a promotion since it can come with a high bonus). While we will use the termination terminology in this section, we will explore the reassignment/promotion option in more detail in Section 4.

As time moves on and no success has been realized, there are 2 countervailing effects on the principal's profits: a direct negative *productivity effect* because the agent is less likely to be talented, and the indirect positive *exploitation effect* because hiring the agent becomes cheaper. The principal's objective is to maximize her expected cumulative myopic, i.e., "per-period", payoffs. Importantly, as the principal is forward-looking, she also takes into account how her current actions modify the distribution over future per-period payoffs. This generates learning benefits: the information gathered over time enables her to make more informed decisions and to re-optimize in the future through reassignment and termination.

To build intuition, though, we will first abstract from these learning benefits, which establish the dynamic link over time, and instead focus on the principal's myopic payoffs as a function of the belief. The myopic payoff represents the principal's payoff in a scenario where she and the agent interact only once. Subsequently, we will clarify how learning benefits arise in our context and, in particular, how the agent's overconfidence affects the optimal extent of learning as well as the duration of the relationship.

Myopic Payoff The principal's myopic (net) payoff of employing the agent equals

$$\mathcal{M}(x^A) := \left[1 + \frac{\Psi x^A}{1+\Psi x^A} a\eta - \frac{1+x^A}{1+\Psi x^A}\Psi c - \bar{\pi}\right].$$

[5] To avoid overwhelming the reader with technical details, we refer to the Appendix, Section 7.1, for a complete formal description.

The myopic payoff contains the value of hiring the agent, 1, plus the (principal-) expected value of the extra profit which is solely a function of her own belief $p^P = \frac{\Psi x^A}{1+\Psi x^A}$. The third term, $\frac{p^P}{p^A}c = \frac{1+x^A}{1+\Psi x^A}\Psi c$, indicates the principal-expected costs of hiring the agent, and the fourth term the opportunity costs of not producing herself. In a first step, we use $\mathcal{M}(x^A)$ to derive the conditions under which the productivity effect dominates the exploitation effect, and vice versa. This will be determined by whether the myopic payoff increases or decreases in the belief x^A, i.e., the sign of

$$\mathcal{M}'(x^A) = \Psi \frac{a\eta - (1-\Psi)\,c}{(1+\Psi x^A)^2}.$$

This yields the following lemma.

Lemma 3 $\mathcal{M}(x^A)$ *is strictly increasing if* $a\eta - (1-\Psi)\,c > 0$, *strictly decreasing if* $a\eta - (1-\Psi)\,c < 0$, *and constant if* $a\eta - (1-\Psi)\,c = 0$.

The sign of $\mathcal{M}'(x^A)$ does not depend on the current belief x^A but only on fundamentals. If the extra benefit $a\eta$ is relatively large, $\mathcal{M}'(x^A) > 0$. Then, the positive productivity effect dominates the negative exploitation effect, and a higher x^A increases (myopic) profits. If, to the contrary, $a\eta$ is relatively small and the agent's overconfidence pronounced, i.e., Ψ is small, then $\mathcal{M}'(x^A) < 0$. In this case, the negative exploitation effect dominates, and a *smaller* belief x^A increases (myopic) profits.

Learning Benefits & Optimal Hiring and Firing In addition to the myopic payoff, the principal also takes potential learning benefits of employing the agent into account. To illustrate these learning benefits, consider a hypothetical scenario under which the principal could commit to permanently employing the agent, consistently compensating him in a way that maximizes profits (as described in Lemma 1). Moreover, note that $\mathcal{M}(x^A)$ can be expressed as $1 - \bar{\pi} + p^P a\eta - (p^P/p^A)c$. Both, p^P and p^P/p^A, are martingales from the principal's perspective (see Lemma 2), implying that also $\mathcal{M}(x^A)$ is a martingale from the principal's perspective. Thus, the principal's expected value when committing to permanently employing the agent at a belief x^A would be $\mathcal{M}(x^A)/r$. However, after "bad" outcomes the principal has the option to discontinue employment and thereby cut her losses. This suggests that, even if myopic profits are (slightly) negative, employing the agent can be optimal if the principal continues employment after some outcomes but terminates it after others. Put differently, if there are beliefs where myopic payoffs are positive and others where they are negative, learning can generate benefits. The idea of sacrificing current payoffs for information that leads to better future decisions is commonly referred to in the literature as *experimentation*.

To relate these insights to our setting, define $V(x^A)$ as the total (net) value of employing the agent, given the current belief is x^A. Thus, it equals the total discounted payoff stream multiplied with the discount rate r (we normalize $V(x^A)$ to attain comparability with the per-period payoff $\mathcal{M}(x^A)$). Therefore, $V(x^A)$ equals the myopic payoff $\mathcal{M}(x^A)$ plus potential benefits of learning. Moreover, the principal's profit-maximizing value $V^*(x^A) = \max\{0, V(x^A)\}$.

Because $V(x^A)$ can differ from $\mathcal{M}(x^A)$ only if $\mathcal{M}(\cdot)$ is positive for some x^A and negative for others, we now discuss the conditions under which $\mathcal{M}(x^A) \geq 0$. For this, we compute the myopic payoff if only failures have been observed and thus beliefs approach zero, $\lim_{x \to 0} \mathcal{M}(x) = 1 - \bar{\pi} - c\Psi$, and the myopic payoff if the agent is known to be talented, $\lim_{x \to \infty} \mathcal{M}(x) = 1 - \bar{\pi} + a\eta - c$. In the following, with a slight abuse of notation we shall write $\mathcal{M}(0)$ for the former and $\mathcal{M}(\infty)$ for the latter.[6] Now, Lemma 3 implies that the sign of $\mathcal{M}'(x^A)$ is independent of x^A and only a function of fundamentals. Therefore, if $\mathcal{M}(0)$ and $\mathcal{M}(\infty)$ both are positive, then $\mathcal{M}(x^A)$ is positive for all x^A and the principal would always want to hire the agent. In this case, there are no benefits of learning, and $V(x^A) = \mathcal{M}(x^A)$. Learning benefits are also absent if $\mathcal{M}(0)$ and $\mathcal{M}(\infty)$ both are negative. Then, $\mathcal{M}(x^A) \leq 0$ for all x^A, and

[6] There is a discontinuity in payoffs at $x^A = 0$, which stems from the fact that, at $x^A = 0$, the contract we are looking at (payments contingent on success) ceases to be possible. As our contract continues to be possible, and (weakly) optimal, when $p^A = p^P = 1$, there is no such discontinuity at $x^A = \infty$.

the principal would never want to hire the agent, implying $V^*(x^A) = 0$ for all x^A. These (and some additional) results are collected in the following proposition, which characterizes the principal-optimal equilibrium for those parameter values for which the principal's learning benefit is nil.[7]

Proposition 1 *The subsequent cases describe the conditions for always or never hiring the agent being optimal.*

1. *If* $\min\{\mathcal{M}(0), \mathcal{M}(\infty)\} \geq 0$*, the principal hires the agent for all* $x^A \in \mathbb{R}_+ \cup \{\infty\}$*. The value function is given by* $V^*(x^A) = \mathcal{M}(x^A) = 1 - \bar{\pi} + \frac{\Psi x^A}{1+\Psi x^A} a\eta - \frac{1+x^A}{1+\Psi x^A} c\Psi$*. If* $a\eta > (1-\Psi)c$*, it is strictly increasing and strictly concave; if* $a\eta < (1-\Psi)c$*, it is strictly decreasing and strictly convex.*
2. *If* $\max\{\mathcal{M}(0), \mathcal{M}(\infty)\} \leq 0$*, the principal does not hire the agent for any* $x^A \in \mathbb{R}_+ \cup \{\infty\}$*. The value function is* $V^* = 0$ *in this case.*

The principal faces a trade-off between getting a sure payoff from not hiring the agent and a risky payoff associated with hiring an agent of uncertain talent. When the value of the agent is low (because the agent's talent is not very important to the principal's production process and there are not many exploitation benefits because the difference in beliefs is modest), the principal prefers never to hire the agent. If, by contrast, the expected value of the agent is high (because the agent's talent is important to the principal and there are large exploitation gains on account of a large difference in beliefs), the principal always hires the agent.[8]

Next, we explore the consequences of $\mathcal{M}(0)$ and $\mathcal{M}(\infty)$ having different signs. If $\mathcal{M}(\infty) > 0 > \mathcal{M}(0)$, a *myopic* principal would hire the agent if and only if $x^A \geq -\frac{1-\bar{\pi}-\Psi c}{\Psi(1-\bar{\pi}+a\eta-c)} =: x^m$, where $\mathcal{M}(x^m) = 0$. If, however, $\mathcal{M}(\infty) < 0 < \mathcal{M}(0)$, a myopic principal would hire the agent if and only if

[7] Note that more detailed versions of Propositions 1–3 can be found in the Appendix. Moreover, all proofs and closed-form solutions of the value functions are also provided in the Appendix.

[8] We are indebted to an anonymous referee for suggesting this intuition.

the belief x^A was *below* the cutoff x^m, i.e., if she was sufficiently pessimistic regarding the agent's talent. Due to the learning benefits, though, the myopic cutoff x^m does not solely determine the principal's hiring decision. Instead, while her hiring decision will still follow a simple cutoff structure – where she hires the agent if x^A is either above or below a certain threshold – this cutoff will differ from x^m. Consequently, the principal might choose to hire the agent even if $\mathcal{M}(\cdot) < 0$. Although this scenario, which we further discuss below, is common in the experimentation literature, our particular context highlights a positive relationship between the agent's overconfidence and the principal's learning benefits. Specifically, the greater the agent's overconfidence, the broader the range of beliefs within which the principal decides to hire the agent.

For the characterization of the principal's optimal decision, we define $x^* := \frac{r}{r+a}x^m$ and $\check{x} := \frac{r+a}{r}x^m$; clearly, $x^* < x^m < \check{x}$. We start with the case $\mathcal{M}'(x^A) > 0$ and $\mathcal{M}(\infty) > 0 > \mathcal{M}(0)$. Then, the principal will hire the agent if and only if she is optimistic enough about his talent, as the following proposition shows.

Proposition 2 *Assume $\mathcal{M}(\infty) > 0 > \mathcal{M}(0)$. Then, the principal hires the agent if and only if $x^A > x^*$. In this range, V^* is strictly increasing.*

If $\mathcal{M}(\infty) = 1 - \bar{\pi} + a\eta - c > 0 > 1 - \bar{\pi} - c\Psi = \mathcal{M}(0)$, the principal is mostly interested in the agent's talent, rather than in her exploitation opportunities. In this case, if $x_0^A > x^*$, the principal will initially hire the agent and keep hiring him until the belief reaches x^* (if $x_0^A \leq x^*$, the principal will never hire the agent). As soon as a success is observed, the agent is hired forever.[9] x^* is smaller than the myopic cutoff, x^m, because of the benefits of

[9]This case is equivalent to a standard one-armed Poisson bandit problem, in which the risky arm is pulled whenever the decision maker is optimistic enough about its quality. The value function in this case is smooth, verifying the usual *smooth pasting* property. As a stylized formalization of the trade-off between experimentation and exploitation, the bandit problem goes back to Thompson (1933) and Robbins (1952). Gittins (1974) showed the structure of the optimal policy; Presman (1991) calculated the *Gittins Index* for the case in which the underlying uncertainty is modeled by a Poisson process.

learning. These make it optimal to hire the agent even if the myopic profits are (slightly) negative.

Second, assume $\mathcal{M}'(x^A) < 0$ and that $\mathcal{M}(\infty) < 0 < \mathcal{M}(0)$. This implies not only that the negative exploitation effect of a higher x^A dominates the positive productivity effect, but also that the myopic profit is positive if the belief is sufficiently low ($x^A \leq x^m$) and negative if the belief is high ($x^A > x^m$).

Then, the principal will hire the agent if and only if she is *pessimistic* enough about his talent, as the following proposition details.

Proposition 3 *Assume $\mathcal{M}(\infty) < 0 < \mathcal{M}(0)$. Then, the principal hires the agent if and only if $x^A \leq \check{x}$. In this range, V^* is strictly decreasing.*

If $\mathcal{M}(\infty) = 1 - \bar{\pi} + a\eta - c < 0 < 1 - \bar{\pi} - c\Psi = \mathcal{M}(0)$, the principal is less interested in the agent's talent than she is in exploiting him. In this case, if $x_0^A \leq \check{x}$, the principal will hire the agent until he produces the extra profit, at which time she will permanently fire him (if $x_0^A > \check{x}$, the principal will never hire the agent). If no success is observed, the agent is hired forever.

The range of beliefs at which the agent is hired is decreasing in Ψ, i.e., increasing for a more overconfident agent, as the following remark shows.

Remark 2 *Less similar beliefs (smaller Ψ), and therefore more exploitation opportunities, lead to a larger set of beliefs at which the agent is hired:*

- *In Proposition 2, $\frac{\partial x^*}{\partial \Psi} > 0$.*
- *In Proposition 3, $\frac{\partial \check{x}}{\partial \Psi} < 0$.*

We end this section by collecting the monotonicity results for the value function.

Remark 3 *The value function V^* is monotonically increasing if and only if $a\eta \geq (1-\Psi)c$; it is constant if and only if $a\eta = (1-\Psi)c$. It is monotonically decreasing if and only if $a\eta \leq (1-\Psi)c$.*

4 Application – Optimal Job Assignment and the Peter Principle

We have demonstrated that the principal benefits from a divergence between her beliefs and those of the agent. However, once the agent has been successful and is revealed to be competent, their beliefs align, and the principal can no longer benefit from an exploitation contract. If the discrepancy was significant, this may result in the principal opting for her outside option following the agent's first success (Proposition 3). Rather than viewing the outside option as terminating the relationship, we now explore its alternative interpretation of reassigning the agent to a different job. In this scenario, we assume that the agent can transition to another position but cannot return to the original one. Due to this "one-way" job rotation, we sometimes refer to such a reassignment as a promotion. This interpretation is further reinforced when the reassignment follows a (first) success that comes with a high bonus, which alternatively could translate into a higher base salary in the new position (as discussed in Section 5.1); then, the reassignment is a move from a lower paying job to a higher paying job, which is a typical feature of a promotion (another typical feature, that multiple agents compete for a promotion, is discussed in Section 4.3 below). We will argue that this interpretation can provide a microfoundation for the well-known "Peter Principle", according to which workers are promoted to their level of incompetence Peter and Hull (1969) or, more precisely, *firms prioritize current performance in promotion decisions at the expense of promoting the candidates with the best potential for the next job* (Benson et al., 2019). Below, we will clearly state how we adapt this definition to our setting.

Assume the agent starts out in the first job, which is as described in Section 2. At a time of her choosing, the principal can assign the agent to a second job where his value to the principal is $\bar{\pi}$; not reassigning him thus entails a flow opportunity cost of $\bar{\pi}$, as before. It is, however, not possible to move the agent back again to the first job. For simplicity, we set the value of firing, or temporarily not employing, the agent in the first job to 0. Importantly, there is no correlation between the jobs regarding the agent's talent for either, and he is (weakly) over-confident concerning the first. Potential overconfidence in the second job is explored in Subsection 4.1.

Clearly, the principal will promote the agent at time $\tau^* = \inf\left\{t \geq 0 \,:\, V^*(x_t^A) < 0\right\}$, where $V^*(x_t^A)$ is the value of employing the agent in the first job net of the value of the outside option $\bar{\pi}$. Generally, our results will depend on whether $a\eta$ is larger or smaller than $(1 - \Psi)c$, i.e., whether $V^*(x^A)$ is increasing or decreasing (see Remark 3).

As a benchmark, we first define the *efficient* reassignment policy, which maximizes the principal's value whose myopic payoff upon hiring the agent is

$$1 + p^P a\eta - \bar{\pi} - c.$$

The efficient reassignment policy would be selected if the principal and agent were the same person or, as we will assume moving forward, if the agent is not overconfident, i.e., $\Psi = 1$. Under this policy, the likelihood of reassigning the agent increases when no success is observed in the first job. Indeed, if $\Psi = 1$, $a\eta > (1 - \Psi)c$, and V^* is increasing in x^A. Thus, the agent will either be reassigned after a long enough history of failures in the first job – or right away or never. This is because the longer history of failures makes the opportunity costs of reassigning the agent less severe. As V^* is monotone for common priors, the following Lemma is immediate:

Lemma 4 *Under the efficient reassignment policy, there is a cutoff $\bar{\pi}(x^A)$ such that the agent is reassigned iff $\bar{\pi} > \bar{\pi}(x^A)$; moreover, $\bar{\pi}(x^A)$ is increasing.*

With common priors, the agent is never reassigned after a success because the jobs are uncorrelated, meaning success in the first job does not imply suitability for the second. In fact, the principal seeks to maximize productive efficiency, balancing the agent's expected productive value in the second job (which remains constant before a promotion) against the opportunity cost of losing the agent in the first job, which increases with x^A.

Next, assume that the agent is overconfident, i.e., $\Psi < 1$. Then, the results derived in Propositions 2 and 3 can be used to show

Proposition 4 *There is a cutoff $\bar{\pi}(x^A, \Psi)$ such that the agent is reassigned if and only if $\bar{\pi} > \bar{\pi}(x^A, \Psi)$. $\bar{\pi}(x^A, \Psi)$ is strictly increasing in x^A if and only if $a\eta > (1-\Psi)c$, strictly decreasing in x^A if and only if $a\eta < (1-\Psi)c$, and constant in x^A if and only if $a\eta = (1-\Psi)c$. For all $x^A < \infty$, $\bar{\pi}(x^A, \Psi)$ is strictly decreasing in the players' belief alignment Ψ, when the principal's belief $x^A \cdot \Psi$ is held constant.*

If $a\eta < (1-\Psi)c$, $V^*(x^A)$ is decreasing and the agent's value goes up over time in the absence of a success. Once a success occurs, the principal's value of keeping the agent in the first job falls because of the eliminated exploitation opportunities. Then, the resulting value reduction increases the relative benefits of a reassignment (i.e., the cutoff $\bar{\pi}(x^A, \Psi)$ drops) even though the success is *not* informative of the agent's talent in the second job.

For the reasons outlined above, we will primarily refer to a reassignment following success as a promotion. In this context, a promotion leads to the Peter Principle, which we define as workers being *intentionally and inefficiently* removed from the job in which they have proven to be productive and placed in another for which they have not yet demonstrated their suitability.

This is a variation of the specification used by Benson et al. (2019), where a promotion policy that results in the Peter Principle emphasizes current performance over future potential for the next role. It is important to note that, as long as the agent's value in the two jobs remains uncorrelated, promoting the agent after a success is always inefficient. In our case, though, the Peter Principle indeed reflects the firm's optimal policy when workers are overconfident. In these instances, the agent is promoted following a success because, once his type is revealed, the value of retaining him in the first job becomes too low for the principal. Below, we will explore additional potential consequences of this policy, such as the possibility of promoting the "wrong" worker.

The question now is under what circumstances the benefits of leveraging overconfidence would outweigh the costs of destroying proven good matches between employees and tasks in real labor markets. According to the condition $a\eta < (1-\Psi)c$, this occurs when the payoff from the agent's talent, η, is not too high, and Ψ is small, indicating significant overconfidence. In Section 4.4, we argue that sales is a notable example, where successful agents are promoted despite not being the most qualified for managerial roles (significant overconfidence was also found among financial-market professionals; see Section 5.1). Furthermore, $a\eta < (1-\Psi)c$ is more likely when the agent's opportunity costs for working with the principal, c, are relatively low. As mentioned in Section 5.3, the size of c could represent labor market competitiveness, with factors like lower labor supply or higher unemployment driving a lower c. Consequently, we would predict that increased competition for workers would amplify the occurrence of the Peter Principle as defined here, although (to the best of our knowledge) no studies have yet examined this link.

Finally, we discuss the optimal reassignment policy if $a\eta > (1-\Psi)c$. In this case, $V^*(x^A)$ is increasing and the general pattern is the same as with common priors ($\Psi = 1$). Either the agent is immediately (or never) reassigned, or he is reassigned after many failures in the first job have sufficiently reduced the opportunity costs of a reassignment. Still, the threshold $\bar{\pi}(x^A, \Psi)$ is higher than with $\Psi = 1$ because the exploitation opportunities in the first job decrease in Ψ (holding the principal's belief $x^A \cdot \Psi$ constant). Therefore, the optimal reassignment policy is also inefficient.

Finally, the last result of Proposition 4 illustrates the fact that the higher the agent's overconfidence the more valuable he is to the principal in the first job.

4.1 Endogenizing $\bar{\pi}$

Now, we endogenize the agent's value in the second job and assume that his overconfidence can extend to it. Assume that the second job also has the features described in Section 2; there is still no correlation between the agent's talent across both jobs. The details can be found in Section 8.1 in the Appendix. As before, the agent's value in the second job remains constant as long as he is not reassigned. Therefore, the same effects as at the top of this section obtain, while introducing the agent's overconfidence in the second job allows for additional comparative statics. The reason is that a reassignment/promotion after a success in the first job re-instates uncertainty and overconfidence, and thus again allows the principal to exploit the agent. Therefore, a lower Ψ in the second job (holding the principal's belief there constant) makes it ceteris paribus more likely that the agent is promoted after a first-job success.

4.2 Correlated Jobs and Endogenous Overconfidence

So far, we have assumed that the agent's talent across both jobs is not correlated. However, even with a positive correlation between jobs, the agent's overconfidence induces the principal to put less weight on the agent's talent for the second job than what the pursuit of productive efficiency would require. Indeed, while a success in the first job then increases players' beliefs concerning the agent's talent for the second job, this increase is less pronounced than the increase in the belief about his talent for the first job (unless correlation was perfect). Therefore, with common priors such a success should make a reassignment *less* likely. With non-common priors, however, promotion will become more likely whenever the belief divergence is important enough (i.e., whenever Ψ is low enough), as the success also eliminates exploitation opportunities in the first job.

Moreover, a success in the first job could also by itself increase the agent's overconfidence. For example, assume that the agent overestimates the *correlation* between talent across both jobs. This could be the result of an inherent bias,[10] or of the principal's subterfuge. Then, our results would only require the agent to naively believe the principal's claim that being successful in the first job is indicative of his potential in the second job. In this case, promoting an agent who has proven to be talented in the first job would again create the additional benefit of being able to exploit his overconfidence in the second job. Importantly, this result would not require the agent to be inherently or initially overconfident – instead his overconfidence would endogenously emerge from a wrong belief that talent in one domain transfers to talent in another.

4.3 Two Agents

Finally, we argue that employing overconfident agents may also lead to the principal putting less weight on an agent's perceived value in the second job when making the decision as to whom among several agents to promote, as compared to the case in which agents are not overconfident. Assume there is some time T at which the principal wants to promote one out of two agents, $i \in \{1, 2\}$. As at the top of Section 4, let the principal's value of promoting agent i, $\bar{\pi}_i$, be solely given by his (expected) inherent talent in the second job. Without loss, we assume that $\bar{\pi}_1 \geq \bar{\pi}_2$. To isolate the role of an agent's overconfidence on the principal's promotion policy and abstract from differences in the opportunity costs of a promotion, we focus on cases in which the principal's belief $\Psi_i x_i^A$ is the same for both agents, while only their Ψ_i might differ. As before, the principal's optimal policy with $\Psi_1 = \Psi_2 = 1$ is based solely on the agent's perceived value in the second job. Then, we say that the *right* agent is promoted, which in our case is agent 1. The policy of promoting agent 1 is also adopted if both agents produce a success before time T. However, the following proposition shows that there exist parameters such that the "wrong" agent will be promoted.

[10] For example, the widely observed self-attribution bias, in which people attribute their success to their own abilities instead of just being lucky (see Daniel et al., 1998 or Billett and Qian, 2008 for evidence in the context of managers), could be a factor leading to the agent's attribution of a first-job success to a general skill that also transfers to other realms.

Proposition 5 *Suppose that agent 1 is more overconfident than agent 2 ($\Psi_1 < \Psi_2$), and suppose that the principal wants to promote one of the agents at a time T at which her beliefs satisfy $\Psi_1 x^A_{1,T} = \Psi_2 x^A_{2,T}$. There exist parameters satisfying $\bar{\pi}_1 > \bar{\pi}_2$ and $\Psi_1 < \Psi_2$ such that the principal promotes agent 2.*

If $\Psi_1 < \Psi_2 \leq 1$, agent 1's value is higher in the first job due to his greater overconfidence. If the difference between $\bar{\pi}_1$ and $\bar{\pi}_2$ is small compared to the difference between Ψ_2 and Ψ_1 (for example if agent 2 has succeeded but agent 1 has not), the principal might choose to promote agent 2. This decision arises because, despite agent 1 being better-suited for the second job, his higher overconfidence makes him less expensive to incentivize in the first job.

Collecting the insights from this and the previous subsections, and assuming the agent's perceived value in the second job remains constant, we can conclude that an overconfident agent is more likely to be promoted if he has demonstrated talent in the first job. Conversely, he is less likely to be promoted if he has not performed well, which stands in contrast to the benchmark scenario of common beliefs. Therefore, if workers are overconfident, we would expect to see a positive correlation between current performance and promotion, even when the requirements for the two jobs are entirely unrelated.

4.4 Evidence

Using microdata on sales workers, Benson et al. (2019) find evidence for productive mismatches, as promotion policies put too much weight on current performance, as opposed to perceived fit for the new job. Although sales clearly are a *verifiable* performance measure, high sales are not only rewarded with cash compensation, but also increase a salesperson's chances of being promoted to a managerial position. This policy disregards managerial potential and is costly because it reduces managerial quality (measured as value added to subordinate sales) by 30% compared to a counterfactual where the ones with the highest managerial potential would be promoted. Benson et al. (2019) discuss a number of potential theoretical explanations for these outcomes which, however, we argue cannot fully rationalize their observations, as they are based on an easily verifiable task (see the Related Literature Section above). Instead, we argue that it is not the nature of the job that renders the promotion of successful sales agents (instead of those with the best fit) optimal, but their personal characteristics. Indeed, there is evidence that sales agents are particularly prone to being overconfident. Sevy (2016), in a Forbes blog, argues that, because of the availability of clear performance indicators, sales is an environment that attracts people who want to prove their ability. Those who go for sales care about personal advancement and not about helping a team thrive; this is different in sales *management*, where holding back one's ego and letting others shine is important.

Moreover, whereas Benson et al. (2019) find that collaboration experience is indicative of better *managerial* performance, so-called "lone wolves," who never collaborate and are known to be highly self confident (Dixon and Adamson, 2011) are significantly more likely to be promoted to a managerial position.

Finally, Bonney et al. (2020) find that salespeople are more overconfident in their assessment of customer opportunities than sales managers, which is striking because sales managers are typically former salespeople who have been promoted into a new role. This result is consistent with our story, if sales managers are promoted because they have proven to be good salespeople and therefore do a better job of evaluating sales opportunities.

5 Discussion and Robustness

In this section, we discuss implications as well as the robustness of our results.

5.1 Performance Pay and Overconfidence

The agent's overconfidence makes it optimal to pay the agent only after success. Thus, empirically, our mechanism seems to generate substantial pay for performance. However, most workers work in industries where performance pay is only a small fraction of compensation (Lemieux et al., 2009). Therefore, the question is whether our mechanism applies primarily in labor-market sectors that can empirically be identified by the presence of substantial pay for performance. We would argue that this is only partially true.

On the one hand, Lemieux et al. (2009) indeed find that sales jobs have the highest incidence of pay for performance, followed by managers.[11] One reason for this is the relative ease of verifying performance in these roles. However, these occupations are also known for widespread overconfidence, which further supports the advantages of pay-for-performance systems. Additionally, substantial evidence suggests that financial-market professionals, such as traders and investment bankers, tend to be overconfident in their knowledge of financial markets or their ability to forecast stock prices (Puetz and Ruenzi, 2011; Glaser et al., 2012; Menkhoff et al., 2013), providing additional support for the link between the prevalence of performance pay and overconfidence.

On the other hand, the optimal structure of the compensation scheme – in which the first success generates the highest payment, especially if it took a long time to materialize – can also be interpreted in the following way. First, if $\mathcal{M}'(x^A) < 0$ and $\mathcal{M}(\infty) < 0$, the negative exploitation effect dominates the positive productivity effect, and the agent may be fired after a success and after receiving a substantial payment. This can be interpreted as a severance payment, which would then increase over the agent's tenure. Second, if the agent is reassigned/promoted after a success, then, instead of a big bonus upon promotion, the compensation could take the form of a fixed wage that is constantly paid in the new position (which would be strictly optimal if the agent is risk averse, as discussed in the next subsection). Note that such a

[11] See Malmendier and Tate (2005), Goel and Thakor (2008), Gervais et al. (2011), Malmendier and Tate (2015), for evidence on overconfidence among managers.

structure would require long-term commitment on the part of the principal, which we rule out. However, reputation mechanisms could serve this purpose, which are likely to be easier to implement and enforce if wages are tied to job titles rather than individual employment histories.

Finally, we would argue that an interesting implication of our (and related) work is to show that pay for performance can be optimal even when it is not necessary to incentivize performance. This argument holds even if the agent is risk-averse, as we discuss next.

5.2 Risk Aversion

Performance pay is optimal in our setting because the principal and the agent have different beliefs about the agent's talent. With risk-neutral players, there must be a constraint on the size of performance pay because otherwise, players would agree on infinite amounts. We assume this constraint is due to the agent's limited liability, which implies that the agent's compensation increases as the likelihood of its payout decreases. Conversely, the compensation the principal *expects* to pay decreases over time in the absence of success. The question is whether these features are a consequence of the limited-liability assumption or if they also emerge under alternative settings. Therefore, we now consider a risk-averse agent, which is a standard friction in agency models (also with an overconfident agent; see Santos-Pinto, 2008, or de la Rosa, 2011). We briefly discuss to what extent the agent's risk aversion affects the optimality of performance pay, which form it takes, and how the agent's compensation evolves over time. A more detailed discussion can be found in the Appendix, in Section 8.2, where we focus on the case in which the principal maximizes her myopic payoff. This still allows us to generate insights into how the agent's compensation conditional on success or on no success, as well as the principal-expected compensation, and the myopic profits evolve.

Now, if compensation was designed as in our main model, then, with small x^A, a high b would be paid with a low probability. This would expose the agent to substantial risk, which is expensive for the principal. Therefore, letting the agent's compensation only be success-based will generally not be optimal and some fixed compensation paid as well. The overall implications of risk aversion will depend on whether the agent has wealth and access to borrowing/savings devices (which we exclude), as well as the specific form of his utility function. We show that, if the agent is overconfident, then using the success-based bonus is always optimal (as long as no success has been realized) even though the agent is risk averse. For specific parameter values, we moreover demonstrate that total compensation goes up over time in the absence of success, and that the principal's myopic payoff conditional on hiring the agent may increase in the absence of success, but only for intermediate values of x^A. For very low x^A, the cost of the agent's risk aversion is too high; for very high x^A, the belief ratio is too close to 1 to allow substantial gains from performance pay.

5.3 Competition

In this section, we discuss how our results are affected by labor-market competition. In this context, it is important to clarify the nature of the agent's type. So far, we have suggested that η represents the agent's (general) talent; however, it could also indicate the quality of the specific match between the principal and the agent. While this distinction is not critical in our main model, it becomes significant in a labor market where potential offers from other firms affect the agent's effective outside option. If the type is match-specific, more intense competition would merely reflect an increase in the agent's reservation utility of working for the principal, c, and be independent of the agent's type. However, if the agent's skills are general and a success is observed by the entire market, the agent's effective outside option changes in response to such a success.

To examine the effects of labor-market competition when the agent's type is general, we analyze a scenario in which multiple identical firms compete for the agent in a Bertrand-style competition, detailed in Section 8.3 of the

Appendix. There, we demonstrate that although the agent captures the full rent of the employment relationship, our primary conclusions remain unchanged, and employment may terminate after a first success: We first establish that each firm earns zero profit at each instant, offering a payment that represents their entire myopic payoff. Importantly, the structure of this offer accounts for the agent's overconfidence and involves a lump sum payment $b = (1 - \bar{\pi})/ap^P + \eta$ provided upon success. The agent accepts this offer as long as the value of being employed – which includes both the myopic payoff and potential learning benefits – exceeds his opportunity costs c. Consequently, the problem again boils down to determining, for each x^A, whether the agent chooses to be employed or not. It turns out that the decision rules mirror those in our main model, establishing belief cutoffs above or below which the agent decides to be employed. This is because the thresholds at which the principal's myopic payoffs in our main model and the agent's myopic payoff under Bertrand competition are positive as $x^A \to 0$ or $x^A \to \infty$ are identical. Additionally, the sign of the derivative of the agent's value remains unaffected by x^A.

Therefore, our results are not contingent on the principal setting the terms of employment but hold even in the face of competition for the agent. In particular, the value decreases in x^A when η and/or Ψ are small, potentially leading to a termination of the relationship after the agent has demonstrated his talent on the job. This occurs because, even with competition, firms find it optimal to offer "performance pay" that accounts for the agent's overconfidence. Our interpretation that the agent might be reassigned instead of terminated can also apply in a competitive labor market. Setting $\bar{\pi} = 0$ would incorporate competition also at the next job, and a sufficiently high value of c would indeed make it optimal to promote the agent after a success.

6 Conclusion

We have studied the ongoing employment relationship between a firm and an overconfident worker. Although the worker learns over time, his exploitation increases, leading to a decrease in the cost of compensating him as long as he has not demonstrated proficiency in his current role. As a result, it may become optimal for the firm to terminate productive matches because the advantages of exploiting the worker's overconfidence have been exhausted. As a result, the worker might be reassigned to a new position, which comes with a high bonus and can thus be seen as a promotion. Thus, we introduce a novel microfoundation for the Peter Principle, suggesting that workers are deliberately and inefficiently removed from roles in which they have demonstrated their productivity and placed in new roles where their competence has yet to be proven.

7 Appendix A—Formal Model, Closed-Form Solutions, & Proofs

7.1 Formal Model Description & Closed-Form Solutions

Given the optimal compensation structure (Lemma 1), the principal's strategy boils down to, at each instant, choosing whether to hire the agent as a function of the previous history. Formally, the principal's hiring decisions are a process $\{\chi_t\}_{t\in\mathbb{R}_+}$ that is predictable with respect to the available information, where $\chi_t = 1$ if the agent is hired at instant t, and $\chi_t = 0$ otherwise. Clearly, since the principal is restricted to offering stationary Markov contracts, it is without loss to restrict the principal to choosing a hiring strategy that is also Markovian, i.e., a process $\{\chi_t\}_{t\in\mathbb{R}_+}$ such that $\chi_t = \chi(x_t^A)$ for all $t \in \mathbb{R}_+$, where $\chi : \mathbb{R}_+ \cup \{\infty\} \to \{0,1\}$ is a time-invariant function of beliefs.[12] In summary, the principal chooses a Markov strategy so as to maximize

$$\Pi(x^A) = \mathbb{E}\left[\int_0^\infty re^{-rt}\left(1 - \frac{\Psi x_0^A}{1+\Psi x_0^A}\left(1 - e^{-a\int_0^t \chi(x_\tau^A)\,d\tau}\right)\right)\chi(x_t^A)\right.$$
$$\left.\times\left(1 - \bar{\pi} - \frac{1+x_t^A}{1+\Psi x_t^A}\Psi c + \frac{\Psi x_t^A}{1+\Psi x_t^A}a\left(\eta + \max\left\{0, \frac{1-\bar{\pi}+a\eta - c}{r}\right\}\right)\right) dt | x_0^A = x^A\right], \tag{1}$$

where the expectation is with respect to the belief process $\{x_t^A\}_{t\in\mathbb{R}_+}$.

Bellman Equation

We now set up the Bellman equation for the problem. By the Principle of Optimality, the principal's value function satisfies

$$V^*(x^A) = \max_{\chi\in\{0,1\}}\left\{\chi r\mathcal{M}(x^A)dt + (1-rdt)\mathbb{E}\left[V^*(x^A + dx^A)|x^A,\chi\right]\right\},$$

[12] Our payoff-maximizing perfect Bayesian equilibrium will thus be a *Markov perfect equilibrium (MPE)* with players' beliefs as a state variable.

where the myopic payoff from hiring the agent, $\mathcal{M}(x^A)$, has been introduced in the main text. Thus, if the optimal $\chi = 0$, $V^*(x^A) = 0$. If the optimal $\chi = 1$,

$$\begin{aligned}&\mathbb{E}\left[V^*(x^A + dx^A)|x^A, \chi\right] \\ =& \frac{\Psi x^A}{1+\Psi x^A} adt \max\{0, 1-\bar{\pi}+a\eta-c\} + \left(1 - \frac{\Psi x^A}{1+\Psi x^A} adt\right)(V^*(x^A)+V^{*\prime}(x^A)dx^A).\end{aligned}$$

Using $dx^A = -ax^A dt$, gives us, after some simple algebra,

$$V^*(x^A) = \max_{\chi \in \{0,1\}} \chi[\mathcal{B}(x^A, V^*) + \mathcal{M}(x^A)],$$

where

$$\mathcal{B}(x^A, V) := \frac{xa}{r}\left[\frac{\Psi}{1+\Psi x^A}\left(\max\{0, 1-\bar{\pi}+a\eta-c\} - V(x^A)\right) - V'(x^A)\right].$$

captures the benefits from learning about the agent's talent. A myopic principal (i.e., one whose discount rate $r \to \infty$) would hire the agent at x^A if and only if $\mathcal{M}(x^A) \geq 0$. The same policy would be optimal if the principal did not update her belief regarding the agent's talent (e.g., because the agent's talent is continuously drawn anew). Clearly, as we set out in the main text, $\mathcal{M}(x^A) \geq 0$ for all x^A if $\min\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \geq 0$; in this case, a myopic principal would always hire the agent.

By the same token, $\mathcal{M}(x^A) \leq 0$ if $\max\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \leq 0$; in this case, a myopic principal would never hire the agent. If $1-\bar{\pi}-c\Psi < 0 < 1-\bar{\pi}+a\eta-c$, $\mathcal{M}(x^A) \geq 0$, and a myopic principal would thus hire the agent, if and only if $x^A \geq -\frac{1-\bar{\pi}-\Psi c}{\Psi(1-\bar{\pi}+a\eta-c)} =: x^m$. If, however, $1-\bar{\pi}+a\eta-c < 0 < 1-\bar{\pi}-c\Psi$, a myopic principal would hire the agent if and only if $x^A \leq x^m$. We note that $x^m \in (0, \infty)$ in both these cases.

Yet, a principal that is not myopic also takes the learning benefit of employing the agent into account. This learning benefit amounts to $\frac{1}{r}$ times the infinitesimal generator of the process of posterior beliefs applied to the value function V.

We write $V^*(x^A) = \max\{0, V(x^A)\}$, where V satisfies the ODE

$$\begin{aligned} &ax^A(1+\Psi x^A)V'(x^A) + (r + \Psi x^A(r+a))V(x^A) \\ &= r\left[(1+\Psi x^A)(1-\bar{\pi}) - (1+x^A)\Psi c + \Psi x^A a\eta\right] + \Psi x^A a \max\{0, 1-\bar{\pi}+a\eta-c\}, \end{aligned}$$

which is solved by

$$\begin{aligned} V(x^A) =& 1-\bar{\pi} + \frac{\Psi x^A}{1+\Psi x^A}a\eta - c\Psi\frac{1+x^A}{1+\Psi x^A} \\ &- \mathbb{1}_{\{1-\bar{\pi}+a\eta-c<0\}}\frac{a}{a+r}\frac{\Psi x^A}{1+\Psi x^A}(1-\bar{\pi}+a\eta-c) + C\frac{{x^A}^{-\frac{r}{a}}}{1+\Psi x^A}, \end{aligned}$$

with C denoting a constant of integration. We furthermore note that[13]

$$\lim_{x^A \downarrow 0} V(x^A) = 1-\bar{\pi}-\Psi c;$$

$$\lim_{x^A \to \infty} V(x^A) = (1-\bar{\pi}+a\eta-c)\left(1-\mathbb{1}_{\{1-\bar{\pi}+a\eta-c<0\}}\frac{a}{a+r}\right);$$

in what follows, we shall write $V(0)$ and $V(\infty)$ respectively for these limits.

If $V(0)$ and $V(\infty)$ have the same sign, the principal's hiring decision under (almost) perfect information will be the same, independently of whether that almost perfect information is positive or negative regarding the agent's talent. It is thus no surprise that the principal will make the same hiring decision for all beliefs, and hence the learning benefit $\mathcal{B} = 0$ in this case, as the following proposition, which restates Proposition 1 from the main text, shows.

Proposition 1 (detailed) *The following cases describe the conditions for always or never hiring the agent being optimal.*

1. *If* $\min\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \geq 0$, $\chi(x^A) = 1$ *for all* $x^A \in \mathbb{R}_+ \cup \{\infty\}$ *is optimal. The value function is given by* $V^*(x^A) = 1-\bar{\pi}+\frac{\Psi x^A}{1+\Psi x^A}a\eta - \frac{1+x^A}{1+\Psi x^A}c\Psi$. *If* $a\eta > (1-\Psi)c$, *it is strictly increasing and strictly concave;*

[13]As we note in the main text, there is a discontinuity in payoffs at $x^A = 0$, which stems from the fact that, at $x^A = 0$, the contract we are looking at (payments contingent on success) ceases to be possible. As our contract continues to be possible, and (weakly) optimal, when $p^A = p^P = 1$, there is no such discontinuity at $x^A = \infty$.

if $a\eta < (1-\Psi)c$, it is strictly decreasing and strictly convex. If $a\eta = (1-\Psi)c$, $V^*(x^A) = 1 - \bar{\pi} - c\Psi$.

2. *If $\max\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \leq 0$, $\chi(x^A) = 0$ for all $x^A \in \mathbb{R}_+ \cup \{\infty\}$ is optimal. The value function is $V^* = 0$ in this case.*

Proofs for our results rely on standard verification arguments; please see Section 7.2 below for details.

In the following propositions, we shall show that, in the cases not covered by Proposition 1, the principal's learning benefit will be strictly positive, and that her hiring decision will admit of a simple cutoff structure. First, if $1-\bar{\pi}-c\Psi < 0 < 1-\bar{\pi}+a\eta-c$, i.e., if the extra profit is important to the principal, meaning that η is large, and the initial disagreement regarding the agent's talent is not too severe, i.e., Ψ is not too low, the principal will hire the agent if and only if he is optimistic enough about his talent, as the following proposition shows.

Proposition 2 (detailed) *If $1-\bar{\pi}-c\Psi < 0 < 1-\bar{\pi}+a\eta-c$, $\chi = \mathbb{1}_{(x^*,\infty]}$, with $x^* = \frac{r}{r+a}x^m$, is optimal. The value function is C^1 and given by*

$$V^*(x^A) = \mathbb{1}_{(x^*,\infty]}(x^A)\left[\frac{x^{A^{-\frac{r}{a}}}C}{1+\Psi x^A} + 1 - \bar{\pi} + \frac{\Psi x^A}{1+\Psi x^A}a\eta - \frac{1+x^A}{1+\Psi x^A}c\Psi\right],$$

where $C = -x^{*\frac{r}{a}}(1+\Psi x^*)\left[1-\bar{\pi}+\frac{\Psi x^*}{1+\Psi x^*}a\eta - \frac{1+x^*}{1+\Psi x^*}c\Psi\right]$ is a constant of integration determined by value matching at $x^A = x^*$. On (x^*,∞), V^* is strictly increasing, and strictly convex (concave) on $(x^*,\tilde{x})$ ($(\tilde{x},\infty)$), for some inflection point $\tilde{x} \in (x^*,\infty)$.

In this case, the principal will either never hire the agent if $x_0^A \leq x^*$, or, if $x_0^A > x^*$, she will initially hire the agent and keep hiring him until the time τ at which the belief $x_\tau^A = x^*$; the agent is fired for good at this time τ. The firing time $\tau = \tau^*$, where $\tau^* := \frac{1}{a}\ln\left(x_0^A/x^*\right)$, if the agent produces no extra profit η in $[0,\tau^*]$; otherwise, $\tau = \infty$, i.e., the agent is hired forever. This case is equivalent to a standard one-armed Poisson bandit problem, in which the risky arm is pulled whenever the decision maker is optimistic enough about its quality. The value function in this case is smooth, verifying the usual *smooth pasting* property. In our case, a success is fully revealing, so that the risky arm will be used forever after a success. In the absence of a success, optimism about its quality wanes continuously; the risky arm will be abandoned forever when beliefs hit a threshold (or we start out below this threshold). The principal's learning benefit shows up in the fact that she will hire the agent below the myopic cutoff x^m; indeed, on $\left(\frac{1}{1+\frac{a}{r}}x^m, x^m\right)$, she is hiring the agent, even though her current payoffs would be higher if she produced herself. The concept of forgoing current payoffs in exchange for information that is then parlayed into better decisions in the future is what the literature commonly refers to as *experimentation*. The extent of experimentation in our model is governed by the discounted arrival rate of information $\frac{a}{r}$; it vanishes as the principal becomes myopic ($r \to \infty$), and becomes large as information arrives quickly (a large).

If, however, $1 - \bar{\pi} + a\eta - c < 0 < 1 - \bar{\pi} - c\Psi$, i.e., if η and Ψ are relatively small, the opposite dynamics obtain. In this case, the extra profit is relatively unimportant to the principal, and the initial disagreement concerning the agent's talent is large. Then, the principal will hire the agent if and only if she is *pessimistic* enough about his talent, as the following proposition details.

Proposition 3 (detailed) *If* $1 - \bar{\pi} + a\eta - c < 0 < 1 - \bar{\pi} - c\Psi$*,* $\chi = \mathbb{1}_{[0,\check{x}]}$*, with* $\check{x} = \frac{a+r}{r}x^m$*, is optimal. The value function in this case is given by* $V^*(x^A) = \mathbb{1}_{[0,\check{x}]}(x^A)\left[1 - \bar{\pi} + \frac{\Psi x^A}{1+\Psi x^A}a\eta - \frac{1+x^A}{1+\Psi x^A}c\Psi - \frac{a}{a+r}\frac{\Psi x^A}{1+\Psi x^A}(1 - \bar{\pi} + a\eta - c)\right]$*; it is* C^1*, except for a convex kink at* $\check{x}$*, flat on* $[\check{x}, \infty)$*, and strictly decreasing and strictly convex on* $(0, \check{x})$*.*

In this case, the principal will either never hire the agent if $x_0^A > \check{x}$, or, if $x_0^A \leq \check{x}$, she will hire the agent until he produces the extra profit, at which time she will fire him forever. In this case, the stopping boundary is not a *regular* boundary, as beliefs can only move away from, rather than toward, the boundary $\check{x}$, over the course of time. As in Keller and Rady (2015), therefore, *smooth pasting* fails, and the value function admits a kink at the boundary. As in the previous case, the extent of experimentation is increasing in the ratio $\frac{a}{r}$, with $\breve{x} = \left(\frac{a}{r}+1\right)^2 x^* = \left(\frac{a}{r}+1\right) x^m$.

7.2 Proofs

7.2.1 Proof of Lemma 1 and Remark 1

The optimality of a binding (PC) immediately follows from our restriction to spot contracts. Thus, it remains to show that the principal cannot do better by ever paying the agent in the absence of a success. Suppose to the contrary that there exists a period t and a history such that the principal pays a flow $w_t > 0$ in the absence of a success and a lump sum of $b_t \geq 0$ after a success. Then, since at an optimum, the agent's participation constraint will bind, we have

$$\frac{x_t^A a}{1+x_t^A} b_t + w_t = c,$$

while the instantaneous (principal-)expected cost is

$$\frac{\Psi x_t^A a}{1+\Psi x_t^A} b_t + w_t.$$

Plugging in the agent's binding participation constraint yields

$$c - x_t^A a b_t \frac{1-\Psi}{(1+\Psi x_t^A)(1+x_t^A)}.$$

As the factor multiplying $x_t^A a b_t$ is (strictly) negative (if $\Psi < 1$), the principal has no incentive (a strict disincentive) to set $w_t > 0$ (on a set of histories with positive measure, if $\Psi < 1$). Thus, it is optimal for the principal to set $b_t = \frac{1+x_t^A}{a x_t^A} c$ (a.s.), leading to a principal-expected cost of hiring of

$$\frac{\Psi x_t^A a}{1+\Psi x_t^A} b_t = \frac{1+x_t^A}{1+\Psi x_t^A} \Psi c.$$

7.2.2 Proof of Lemma 2

The only claim that is not immediately obvious from inspection is that $\frac{1+x_t^A}{1+\Psi x_t^A}\Psi c$ is a martingale on the principal's information filtration. We have

$$\mathbb{E}\left[d\,\frac{1+x^A}{1+\Psi x^A}\Psi c\right] = \frac{x^A\Psi a}{1+\Psi x^A}cdt+\left(1-\frac{x^A\Psi a}{1+\Psi x^A}dt\right)\left[\frac{1+x^A}{1+\Psi x^A}\Psi c - x^A a\frac{1-\Psi}{1+\Psi x^A}\right]+o(dt)$$

$$=\frac{\Psi c}{1+\Psi x^A}dt\left\{x^A a-\frac{x^A\Psi a}{1+\Psi x^A}(1+x^A)-x^A a\frac{1-\Psi}{1+\Psi x^A}\right\}+o(dt)=o(dt).$$

7.2.3 Proof of Propositions 1–3

We shall write

$$\hat{V}(x^A)=1-\bar{\pi}+\frac{\Psi x^A}{1+\Psi x^A}a\eta-c\Psi\frac{1+x^A}{1+\Psi x^A}-\mathbb{1}_{\{1-\bar{\pi}+a\eta-c<0\}}\frac{a}{a+r}\frac{\Psi x^A}{1+\Psi x^A}(1-\bar{\pi}+a\eta-c)$$

for the principal's payoff of never firing the agent in the absence of a success.

In all four cases, the proposed policy χ implies a well-defined law of motion of the belief x^A, and the closed-form expression for V^* is the payoff function associated with the policy χ. To prove optimality of χ, it suffices to show that $\mathcal{B}(x^A,V^*)\geq-\mathcal{M}(x^A)$ ($\mathcal{B}(x^A,V^*)\leq-\mathcal{M}(x^A)$) whenever $\chi=1$ ($\chi=0$) on some open subset of $\mathbb{R}_+$.

For Proposition 1, Case (1.), direct computation shows that $\mathcal{B}(x^A,\hat{V})\geq-\mathcal{M}(x^A)$ for all $x^A\geq 0$. Moreover, $\hat{V}'>0>\hat{V}''$ if $a\eta>(1-\Psi)c$, $\hat{V}'<0<\hat{V}''$ if $a\eta<(1-\Psi)c$, and $\hat{V}=1-\bar{\pi}-c\Psi$ if $a\eta=(1-\Psi)c$.

In Case (2.), $\mathcal{B}(x^A,V^*)=\mathcal{B}(x^A,0)=0$, for all $x^A\geq 0$. Thus, all that remains to be shown is that $\mathcal{M}^*(x^A)\leq 0$ for all $x^A\geq 0$. As $\mathcal{M}$ is increasing, this is equivalent to $\lim_{x\to\infty}\mathcal{M}(x)=1-\bar{\pi}-c+a\eta\leq 0$, which holds by the definition of Case (2.).

Let us turn to Proposition 2. For $x^A<x^*$, $V^*(x^A)=0$ and $\mathcal{B}(x^A,V^*)=\frac{\Psi x^A a}{r(1+\Psi x^A)}(1-\bar{\pi}+a\eta-c)$. Direct computation shows that $\mathcal{B}(x^A,V^*)\leq-\mathcal{M}(x^A)$ for $x^A<x^*$. For $x^A>x^*$, one shows by direct computation that $\mathcal{B}(\cdot,V^*)>$

$-\mathcal{M}(\cdot)$ in this range. Thus, $\chi = \mathbb{1}_{(x^*,\infty]}$ is optimal. Direct computation furthermore shows that $\lim_{x\downarrow x^*} V^{*'}(x) = 0$ and $V^{*'}(x^A) > 0$ for all $x^A > x^*$. By the same token, direct computation shows that $\lim_{x\downarrow x^*} V^{*''}(x) > 0$, $\lim_{x\to\infty} V^{*''}(x) < 0$, while $V^{*'''}|_{(x^*,\infty)} < 0$.

We now turn to Proposition 3. For $x^A > \check{x}$, $V^*(x^A) = \mathcal{B}(x^A, V^*) = 0$. By the same token, $\mathcal{M}(x^A) \leq 0$ if and only if $x^A \geq x^m = \frac{r}{a+r}\check{x}$. For $x^A < \check{x}$, one shows by direct computation that $\mathcal{B}(\cdot, V^*) > -\mathcal{M}(\cdot)$ in this range. Thus, $\chi = \mathbb{1}_{(0,\check{x}]}$ is optimal. Direct computation furthermore shows that $V^{*''}|_{(0,\check{x}]} > 0$, and that $\lim_{x\uparrow\check{x}} V^{*'}(x) < 0$.

7.2.4 Proof of Proposition 5

The claim immediately follows from continuity and the fact that V_i^* is strictly decreasing in Ψ_i (when $\Psi_i \cdot x_i^A$ is held constant).

8 Appendix B—Microfoundation & Robustness

8.1 Microfoundation for Second Job

The purpose of this subsection is to show how to extend the model so as explicitly to incorporate the second job. Specifically, we shall denote $x_0^A \in (0,\infty)$ $(\Psi_x x_0^A)$ the agent's (principal's) belief (measured in odds ratios, as before) that the agent is talented for the first job, and hence produces the extra profit $\eta_x > 0$ at the rate $a_x > 0$ in the first job. By the same token, we shall write $y_0^A \in (0,\infty)$ $(\Psi_y y_0^A)$ for the agent's (principal's) belief that the agent is talented for the second job, and hence produces the extra profit $\eta_y > 0$ at the rate $a_y > 0$ in the second job. Flow opportunity costs in either job are $c_x > 0$, and $c_y > 0$, respectively.

We continue to assume that the agent is (weakly) overconfident regarding both jobs, i.e., that $\Psi_x \leq 1$ and $\Psi_y \leq 1$. Since talent across jobs is uncorrelated, we have $y_t^A = y_0^A$ for all times t at which the agent is employed in the first job. Both parties discount future payoffs at the rate $r > 0$. After the agent has been reassigned/promoted to the second job, the principal, as before, receives a flow payoff of $\bar{\pi}_y \geq 0$ if she does not hire the agent. Before the agent is reassigned, the principal receives a flow payoff of $\bar{\pi}_x \geq 0$ if she does not hire the agent. We shall write V_x^* for the agent's value to the principal in the first job, ignoring the possibility of reassignment to the second job. Clearly, the principal will reassign the agent at time $\tau^* = \inf\left\{t \geq 0 \,:\, \bar{\pi}_x + V_x^*(x_t^A) < \bar{\pi}_y + V_y^*(y_0^A)\right\}$.

The value functions V_x^* and V_y^* are computed as above. Before the agent is reassigned, $y_t^A \equiv y_0^A$, and therefore $V_y^*(y_t^A) \equiv V_y^*(y_0^A)$, remain constant, while x_t^A, and hence $V_x^*(x_t^A)$, evolve as described above. The key to our subsequent analysis is the monotonicity of the value function, which we have noted in Remark 3. In particular V_i^* ($i \in \{x, y\}$) is strictly increasing (decreasing) if and only if $a_i\eta_i > (1 - \Psi_i)c_i$ ($a_i\eta_i < (1 - \Psi_i)c_i$), and constant if and only if $a_i\eta_i = (1 - \Psi_i)c_i$.

As before a reassignment, y_t^A, and hence $V_y^*(y_t^A)$, remain constant, only the monotonicity of V_x^*, and hence the properties of the first job, matter for the dynamics. In particular, for arbitrary parameters for the second job:

- If $a_x\eta_x > (1-\Psi_x)c_x$, the agent is reassigned after a long enough dearth of lump sums $[0, \tau^*]$, with $\tau^* \in [0, \infty]$;
- if $a_x\eta_x < (1 - \Psi_x)c_x$, the agent is reassigned either right away, never, or at the arrival time of the first lump sum in the first job;
- if $a_x\eta_x = (1-\Psi_x)c_x$, the agent is either reassigned right away or never.[14]

Reassignment dynamics thus depend only on the characteristics of the first job. In particular, the agent is reassigned after a long enough streak of failures if $a_x\eta_x > (1 - \Psi_x)c_x$. If $a_x\eta_x = (1 - \Psi_x)c_x$, his performance in the first job does not matter; he either stays in the first job forever, or is

[14]This is neglecting the knife-edge case where $V_x^* = 1 - \bar{\pi}_x - \Psi_x c_x = V_y^*(y_0^A)$; in this case, the principal is indifferent over all promotion times in $[0, \infty]$, independently of the history.

immediately affected to the second job. If $a_x\eta_x < (1-\Psi_x)c_x$, the agent is reassigned/promoted as soon as he has proven his productivity in the first job by a success, which we interpret as a manifestation of the Peter Principle.

Thus, if $a_x\eta_x \leq (1-\Psi_x)c_x$, the agent is either promoted right away or never in the absence of a success. If $a_x\eta_x > (1-\Psi_x)c_x$, however, the agent is never reassigned after a success, but, in the absence of a success, may be reassigned at any time $\tau^* \in [0,\infty]$, the exact realization of which depends on the precise parameter values.

8.2 Risk Aversion – Detailed Analysis

Here, we present a more detailed discussion of the implications of the agent being risk averse. Because a complete analysis of this case is beyond our scope, we focus on discussing the case in which the principal maximizes her myopic payoff. This still allows us to generate insights into how the agent's compensation conditional on success or on no success, as well as the principal-expected compensation and the myopic profits evolve. Also recall that, in our main model, when $\mathcal{M}(x^A)$ is increasing/decreasing, the same holds for the principal's value.

Now, suppose that over a time interval $[t, t+dt)$, the agent receives a flow utility of $u(w)dt$, with $u' > 0$, $u'' < 0$ and $\lim_{w\to 0} u'(w) = \infty$. If a success is realized, which happens with probability $\theta a dt$, the agent also receives a bonus b and obtains utility $v(w;b)$, with $v(w;b) = u(w+b) - u(w)$.

Moreover, the agent has no alternative source of income, and borrowing/saving are not possible (without these restrictions, risk aversion would matter less and our analysis would be closer to our baseline case). His reservation utility over this time interval is cdt.

Therefore, the agent's expected utility if working for the principal is

$$u(w)dt + ap^A dt\,(u(w+b) - u(w)),$$

and the (PC) constraint becomes

$$\left[(1-ap^A)u(w)+ap^A u(w+b)\right]dt \geq cdt.$$

Our objective is to maximize the principal's myopic profits $\mathcal{M}(x^A)=\max\left\{0,\ \left(1+p^P a\left(\eta-b\right)-w\right)dt\right\}$, subject to the (PC) constraint. This yields

Proposition 6 *Assume the agent is risk averse as specified above. Then, if the agent is hired, the profit-maximizing compensation scheme is characterized by the following optimality conditions:*

$$\begin{aligned}&\left[1+(1-a)\,\Psi x^A\right]u'\left(w+b\right)-\Psi\left[1+(1-a)\,x^A\right]u'\left(w\right)=0,\\ &axu\left(w+b\right)+\left[1+(1-a)\,x^A\right]u\left(w\right)-\left(1+x^A\right)c=0.\end{aligned}$$

Therefore, $w>0$ for all x^A; $b>0$ if $x^A<\infty$ and $\Psi<1$. If the agent is known to be talented, $b=0$ is strictly optimal.

Proof: Note that $\lim\limits_{W\to 0}u'(W)=\infty$ implies that w is positive for all x^A. Assuming that the principal hires the agent, maximizing the principal's myopic profits $\left(1+p^P a\left(\eta-b\right)-w\right)dt$ subject to (PC) – which clearly binds in a profit-maximizing equilibrium – yields the following Lagrangian and first-order conditions

$$
\begin{aligned}
L =& 1+\frac{\Psi x^{A}}{\left(1+\Psi x^{A}\right)}a\left(\eta-b\right)-w\\
&+\lambda_{PC}\left[a\frac{x^{A}}{\left(1+x^{A}\right)}u\left(w+b\right)+\left(1-a\frac{x^{A}}{\left(1+x^{A}\right)}\right)u\left(w\right)-c\right]
\end{aligned}
$$

$$
\begin{aligned}
\frac{\partial L}{\partial w} =& -1+\lambda_{PC}\left[a\frac{x^{A}}{\left(1+x^{A}\right)}u'\left(w+b\right)+\left(1-a\frac{x^{A}}{\left(1+x^{A}\right)}\right)u'\left(w\right)\right]=0\\
\Rightarrow& \lambda_{PC}=\frac{1}{\left[a\frac{x^{A}}{(1+x^{A})}u'\left(w+b\right)+\left(1-a\frac{x^{A}}{(1+x^{A})}\right)u'\left(w\right)\right]}\\
\frac{\partial L}{\partial b} =& -\frac{\Psi x^{A}}{\left(1+\Psi x^{A}\right)}a+\lambda_{PC}\left[a\frac{x^{A}}{\left(1+x^{A}\right)}u'\left(w+b\right)\right]=0\\
\Rightarrow& -\frac{\Psi x^{A}}{\left(1+\Psi x^{A}\right)}a+\frac{\left[a\frac{x^{A}}{(1+x^{A})}u'\left(w+b\right)\right]}{\left[a\frac{x^{A}}{(1+x^{A})}u'\left(w+b\right)+\left(1-a\frac{x^{A}}{(1+x^{A})}\right)u'\left(w\right)\right]}=0\\
\Rightarrow& u'\left(w+b\right)\left[1+\left(1-a\right)\Psi x^{A}\right]-\Psi\left[1+x^{A}\left(1-a\right)\right]u'\left(w\right)=0
\end{aligned}
$$

As the sufficient condition for a maximum holds, the optimality conditions are

$$
\left[1+\left(1-a\right)\Psi x^{A}\right]u'\left(w+b\right)-\Psi\left[1+\left(1-a\right)x^{A}\right]u'\left(w\right)=0 \qquad \text{(FOC)}
$$

$$
ax^{A}u\left(w+b\right)+\left[1+\left(1-a\right)x^{A}\right]u\left(w\right)-\left(1+x^{A}\right)c=0 \qquad \text{(PC)}
$$

Since $\Psi\left[1+\left(1-a\right)x^{A}\right]/\left[1+\left(1-a\right)\Psi x^{A}\right]<1$ for $\Psi<1$, (FOC) implies that $b>0$ for all x^{A}. Thus, the agent is paid a success-based bonus irrespective of the extent of his risk aversion.

To show that, for $u(w)=\ln(w)$, total compensation $W=w+b$ decreases in x^{A} (i.e., increases over time as long as no success is generated), note that

$$
\begin{aligned}
W =& w + b \\
=& w \frac{1 + \Psi (1 - a) x^A}{\Psi [1 + (1 - a) x^A]}
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{\partial W}{\partial x^A} =& \frac{\partial w}{\partial x^A} \frac{1 + \Psi (1 - a) x^A}{\Psi [1 + (1 - a) x^A]} \\
& - w \frac{(1 - a)(1 - \Psi)}{\Psi [1 + (1 - a) x^A]^2} \\
=& - \frac{w \left[(1 - a)(1 - \Psi) + \frac{a\left[1+\Psi(1-a)x^A\right] ln\left(\frac{\left[1+(1-a)\Psi x^A\right]}{\Psi\left[1+(1-a)x^A\right]}\right)}{(1+x^A)} \right]}{\Psi (1 + x^A) [1 + (1 - a) x^A]} \\
& < 0
\end{aligned}
$$

Interestingly, if the agent is overconfident, then as long as no success has been realized, using the success-based bonus is always optimal even though the agent is risk averse. Therefore, we argue that overconfidence provides an additional rationale for the use of performance pay. This is reminiscent of a classic result in portfolio theory, which states that an investor, regardless of his level of risk aversion, should always invest some of his wealth in a risky asset if that asset yields a positive net return.

Using the optimality conditions derived for Proposition 6, wage and bonus if the agent is hired become

$$
\begin{aligned}
b =& \left(\frac{1 - \Psi}{\Psi [1 + (1 - a) x^A]} \right) w \\
\ln (w) =& \frac{\left(1 + x^A\right) c - ax\ln \left(\frac{\left[1+(1-a)\Psi x^A\right]}{\Psi[1+(1-a)x^A]} \right)}{1 + x^A}.
\end{aligned}
$$

The latter implies that, for $x^A \rightarrow \infty$, $\ln (w) \rightarrow c$. We have just shown that $w + b$ decreases in x^A. Therefore, as with a risk-neutral agent, total compensation goes up over time in the absence of success.

To gain further insights, we assume $a = 0.5$ and $c = 1$, and present some results for the principal-expected compensation,

$$\begin{aligned} & w + ap^P b \\ = & \frac{\left(1 + x^A\right) \left[1 + x^A \Psi \left(1 - a\right)\right]}{\left(1 + \Psi x^A\right) \left[1 + \left(1 - a\right) x^A\right]} w. \end{aligned}$$

For $\Psi = 0.2$, the principal-expected compensation has a minimum at $x^A = 1.17$ (i.e., at $p^A = 0.54$ and $p^P = 0.19$), and is increasing for lower and decreasing for higher values. For $\Psi = 0.5$, the principal-expected compensation has a minimum at $x^A = 0.82$ ($p^A = 0.45$ and $p^P = 0.29$). For $\Psi = 0.8$, it has a minimum at $x^A = 0.68$ ($p^A = 0.40$, $p^P = 0.35$).

Therefore, as with risk neutrality, the principal-expected compensation may decrease as long as no success occurs, but only if x^A is sufficiently high. Then the effect of the reduction in relative beliefs more than compensates for the agent's risk costs.

To assess the evolution of the principal's myopic profit $\mathcal{M}(x^A)$, we assume that the agent is hired for all x^A. There, we would have to assume that the base profit from hiring the agent is larger than 1 (or that $\bar{\pi}$ is negative) because, with $u(w) = \ln(w)$, the principal-expected compensation is always larger than 1 unless Ψ is very small. However, since neither the base profit nor $\bar{\pi}$ interact with x^A, their size has no effect on the comparative statics conditional on hiring the agent, for which only the term

$$p^P a \left(\eta - b\right) - w = \frac{\Psi x^A}{\left(1 + \Psi x^A\right)} a\eta - \frac{\left(1 + x^A\right) \left[1 + x^A \Psi \left(1 - a\right)\right]}{\left(1 + \Psi x^A\right) \left[1 + \left(1 - a\right) x^A\right]} w$$

is relevant.

We first assume that the payoff of obtaining a success, $\eta = 1$. In this case, for $\Psi = 0.2$, $\mathcal{M}(x^A)$ increases from $x^A = 0$ to $x^A = 2.30$ ($p^A = 0.70$, $p^P = 0.32$), then decreases until $x^A = 8.68$ ($p^A = 0.90$, $p^P = 0.63$), after which it increases again. For Ψ exceeding ~ 0.23, $\mathcal{M}(x^A)$ increases for all x^A.

If $\eta = 0.1$ and $\Psi = 0.2$, $\mathcal{M}(x^A)$ increases from $x^A = 0$ to $x^A = 1.23$ ($p^A = 0.55$, $p^P = 0.20$), then decreasing until $x^A = 165.95$ ($p^A = 0.99$, $p^P = 0.97$), after which it increases again. For $\Psi = 0.5$, $\mathcal{M}(x^A)$ increases from $x^A = 0$ to $x^A = 1.11$ ($p^A = 0.53$, $p^P = 0.36$), then decreases until $x^A = 21.90$ ($p^A = 0.96$, $p^P = 0.92$), after which it increases again. For Ψ exceeding ~ 0.65, $\mathcal{M}(x^A)$ increases for all x^A.

Therefore, as with risk neutrality (and limited liability), the myopic payoff conditional on hiring the agent may increase in the absence of success, but only for intermediate values of x^A. For very low x^A, the cost of the agent's risk aversion is too high; for very high x^A, the belief ratio is too close to 1 to allow substantial gains from performance pay.

8.3 Competition – Detailed Analysis

Assume $N \geq 2$ identical firms compete to hire the agent in a frictionless labor market. Each firm's expected revenues when employing the agent, is given by $(1 + \theta a \eta)\, dt$ at any point in time. At each instant, firms simultaneously make employment offers to the agent in a Bertrand-style competition. Similar to our main model, these offers include a flow payment w if there is no success, and a lump sum b if the agent achieves a success.

The agent accepts the offer that provides the highest perceived utility flow and randomizes if he is indifferent between two or more offers. Information is fully transparent, so the entire market can observe whether the agent has achieved a success. Still, the agent incurs *inherent* opportunity costs c, which may include unemployment benefits, effort costs, and other factors. The rest of the model follows the main part; in particular, the agent is overconfident. Consequently, all firms will find it optimal to compensate the agent only with the lump sum b, meaning they only pay him if he achieves a success.

The myopic profits of the firm whose offer is accepted by the agent are given by

$$\mathcal{M}(x^A) = 1 - \bar{\pi} + \frac{\Psi x^A}{1 + \Psi x^A} a (\eta - b) .$$

Bertrand competition ensures that the on-path value of all firms in this market will be zero after any history. This implies that firms cannot benefit from potential learning benefits, and their *myopic* profits are zero at each point in time.

This yields

$$b = \frac{\left(1 + \Psi x^A\right)}{a \Psi x^A} (1 - \bar{\pi}) + \eta.$$

The agent must decide whether to accept this offer at each instant. Thus, our optimization problem is to maximize the agent's value subject to the constraint that the principal's principal-expected myopic profits are zero for each x^A, along with the non-negativity constraints from the main model. Therefore, while firms focus solely on their myopic payoffs, the agent now takes potential learning benefits into account. Still, it turns out that the agent's optimal decisions will depend on the characteristics of his myopic payoff, net of his opportunity cost c. At each instant, he expects to receive the lump sum b with a perceived probability of ap^A, leading to an expected myopic payoff of $ap^A b - c$, or

$$\mathcal{M}_A(x^A) = \frac{1 + \Psi x^A}{\Psi(1 + x^A)} (1 - \bar{\pi}) + \frac{x^A}{1 + x^A} a\eta - c,$$

with

$$\mathcal{M}'_A(x^A) = \frac{a\eta - \frac{(1-\Psi)}{\Psi} (1 - \bar{\pi})}{(1 + x^A)^2}.$$

If $a\eta < (1 - \bar{\pi}) (1 - \Psi) / \Psi$, then $\mathcal{M}'_A(x^A) < 0$, indicating that $\mathcal{M}_A(x^A)$ increases as long as no success has been realized. Similar to our main setting, it turns out that the agent's value function – representing his total value of accepting employment, which takes potential learning benefits into account – inherits the monotonicity properties of the agent's myopic payoff.

Moreover, recall that, if we maximize the principal's profits, the derivative of the principal's myopic profit (and thus her value function), $\mathcal{M}'(x^A)$, is negative if $c > a\eta/(1-\Psi)$. Therefore, in both cases the value decreases with x^A when η and/or Ψ are small.

Proposition 7 below shows that employment decisions are the same as in our main model. Therefore, it does not matter whether we maximize the principal's or the agent's value (although the ranges for which the respective value functions are increasing or decreasing if the agent is always hired differ slightly). This is because

$$\mathcal{M}_A(\infty) = 1 - \bar{\pi} + a\eta - c = \mathcal{M}(\infty)$$

and, since $\mathcal{M}_A(0) = (1 - \bar{\pi} - \Psi c)/\Psi$,

$$\Psi\mathcal{M}_A(0) = 1 - \bar{\pi} - \Psi c = \mathcal{M}(0).$$

Thus, the thresholds above which the myopic payoffs are positive in the limits $x^A \to 0$ and $x^A \to \infty$ are identical. Moreover, whether myopic payoffs are increasing or decreasing is independent of x^A. Consequently, if $\mathcal{M}(\infty) > \mathcal{M}(0)$ and consequently $\mathcal{M}' > 0$, the same holds for $\mathcal{M}_A(x^A)$.

Proposition 7 *Solving for a PBE that maximizes the agent's utility (given his beliefs) yields the following outcomes.*

- *If* $\min\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \geq 0$*, the agent accepts an employment offer for all* $x^A \in \mathbb{R}_+ \cup \{\infty\}$*. The agent's value function is given by* $V_A^*(x^A) = \mathcal{M}_A(x^A) = \frac{1+\Psi x^A}{\Psi(1+x^A)}(1-\bar{\pi}) + \frac{x^A}{1+x^A}a\eta - c$*. If* $a\eta > \frac{(1-\Psi)}{\Psi}(1-\bar{\pi})$*, it is strictly increasing and strictly concave; if* $a\eta < \frac{(1-\Psi)}{\Psi}(1-\bar{\pi})$*, it is strictly decreasing and strictly convex.*

- *If* $\max\{1-\bar{\pi}-c\Psi, 1-\bar{\pi}+a\eta-c\} \leq 0$*, the agent rejects the offers for all* $x^A \in \mathbb{R}_+ \cup \{\infty\}$*. The agent's value function is* $V_A^* = 0$ *in this case.*

- *If* $1-\bar{\pi}+a\eta-c > 0 > 1-\bar{\pi}-c\Psi$, *the agent accepts an offer if and only if* $x^A > x^*$, *where* x^* *is the same as in Proposition 2. In this range,* V_A^* *is strictly increasing.*

- *If* $1-\bar{\pi}+a\eta-c < 0 < 1-\bar{\pi}-c\Psi$, *the agent accepts an offer if and only if* $x^A \leq \check{x}$, *where* $\check{x}$ *is the same as in Proposition 3. In this range,* V_A^* *is strictly decreasing.*

Proof:

We derive equilibrium contracts that maximize the agent's expected utility (according to the agent's assessment) subject to the constraint that the principal achieve an expected profit of at least 0, according to the principal's assessment. The principal's binding participation constraint pins down the agent's reward in case of a success $b_t = \frac{1+\Psi x_t^A}{\Psi x_t^A a}(1-\bar{\pi})+\eta$, leading to an agent-expected myopic payoff for the agent of $\mathcal{M}_A(x^A) = \frac{1+\Psi x^A}{\Psi(1+x^A)}(1-\bar{\pi})+\frac{x^A a}{1+x^A}\eta - c$. We note that this myopic payoff $\mathcal{M}_A$ is increasing (decreasing) if and only if $\Psi a\eta \geq (\leq)\ (1-\Psi)(1-\bar{\pi})$.

This in turn leads to the following ODE for the agent's payoff $U(x^A)$,

$$x^A(1+x^A)aU'(x^A)+(r(1+x^A)+x^A a)U(x^A) = r(1+x^A)\mathcal{M}_A(x^A)+x^A a\max\{1-\bar{\pi}+a\eta-c,0\}.$$

Solving the ODE, and going through the same verification steps as in the baseline model[15] yields the same results as in the baseline model; i.e., the parameter ranges and threshold values of Propositions 1–3 continue to apply.

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