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# The optimal disclosure policy when firms offer implicit contracts

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*The observability of history is crucial for the sustenance of implicit (or relational) contracts. When a firm hires a sequence of short-lived workers, turnover adversely affects the observability of history—the old worker may leave the firm before communicating the history to the young. However, turnover can also enhance profits if matching gains can be extracted up front. Disclosure of the workers' productivity information affects turnover by mitigating adverse selection. Thus, the optimal disclosure policy trades off matching efficiency with the sustainability of implicit contracts. I show that (i) opaqueness can be optimal only for firms with moderate reputation concerns, and (ii) an opaque firm's profit may decrease with its reputation concern.*

## 1. Introduction

■ Firms often offer implicit (or relational) contracts to motivate their workers, especially when appropriate verifiable measures of the workers' performance are difficult to obtain (Bull, 1987; Levin 2003).[1] An implicit contract is an informal promise of a performance-based reward that the firm makes to its workers (e.g., bonus payments). Such promises are sustained through the threat of the workers' future retaliation, which is triggered if the firm reneges on its promise. Therefore, if the firm is to credibly offer an implicit contract, workers must be able to clearly observe the history of the game. If a defection by the firm goes unobserved, the threat of future retaliation that sustains implicit contracts disappears.

However, employee turnover may obscure the history of the game.[2] If one considers a firm as a long-run player hiring a sequence of short-run workers, one may argue that the coexistence of the young and the old workers facilitates the worker's observability of the game's history. Both the economics of organization and the organizational behavior literature highlight the role of interaction between workers as the key conduit for information transmission within an

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[1] Such contracts are also referred to as "self-enforcing implicit" contracts by some authors (Bull, 1987).

[2] Job-to-job turnover is becoming more commonplace. Topel and Ward (1992) report that an average U.S. worker holds as many as seven jobs in the first ten years of his career. Fallick and Fleischman (2004) find that "on average 2.6% of employed persons change employers each month, a flow twice as large as that from employment to unemployment."

organization (Crémer, 1993; Hermalin, 2001; Fisher and White, 2000). Turnover adversely affects the observability of history, because it weakens the network of interaction among the old and the young employees. As a result, it stifles the diffusion of information (including information on the firm's past behavior) across different generations of workers. Therefore, a firm with a high turnover rate may face a lesser threat of retaliation following a breach of its implicit contracts. When the information trickles slowly, it delays the triggering of punishment by workers. Because future payoffs are discounted, a delayed punishment is tantamount to a milder punishment. And at the extreme, the firm's deviation might go unpunished altogether if the history of its past deviation is never observed by its future generation of workers.

The popular press has documented such situations in real life. Stewart (1993) discusses the turmoil at First Boston, a renowned investment-banking firm on Wall Street, that followed from a breach of implicit contract. The firm's below-par bonus announcements created dissent among the workers. "Morale was so bad . . . that many traders seemed to drag their heels, further depressing the firm's earnings." One can interpret the lower earnings as the retaliation, that is, the "punishment phase" payoff to First Boston. However, the punishment phase was short lived. Soon, the dissent led to a huge turnover. The top management was lured away by various raiding firms, and new hires were brought in to fill in their place. A senior partner speculates that "maybe the new First Boston will be very successful, but you will lose the old First Boston. Maybe the new First Boston doesn't care." The case of First Boston highlights the role of turnover in salvaging a firm from the punishment phase. However, due to this very reason, turnover imposes a cost on the firm. It impairs a firm's incentive provisions by eroding its ability to credibly promise an implicit contract in the first place.

Indeed, many organizations aim to build a "high-commitment" environment by limiting turnover so as to ensure that the workers are motivated to work for the best interest of the firm. Firms adopt various means to foster such a high commitment environment. Employment guarantees, careful recruiting to ensure fit, and extensive training are some of the oft-cited strategies that firms adopt to reduce turnover. Because the relationship between the firm and the workers is a long-lasting one in a high-commitment environment, the firm enjoys significant credibility in promising reward for performance. Consequently, these firms can easily motivate their workers to exert consummate effort. Such practice of a high-commitment environment is extremely common among the top-tier Japanese organizations (e.g., Toyota, Mitsubishi Trading Co., etc.) as well as some of the information technology firms in United States (see Baron and Kreps, 1999).

However, turnover may also have its benefits that can enhance the firm's profit. If the workers are better matched with their prospective employers, the initial employer's profit may include the matching gains that the worker expects to earn when he switches jobs. If the initial employer anticipates that its worker will subsequently get high-wage offers from the raiding firms, it may extract the matching gains from its worker by lowering the initial wage offer and, consequently, enhance profit. Thus, the initial employer may like to ensure an efficient level of turnover in order to maximize the matching gains available for extraction.

Greenwald (1986) argues that the turnover process can be severely affected by an adverse selection problem. Because the initial employer typically possesses better information about the productivity of its workers (e.g., it may have observed the worker's performance in the past), prospective employers may suffer from an informational disadvantage.

Therefore, an important question in the organization of a firm is: how much information about its worker's performance should it disclose to the outside labor market? Disclosure of the workers' productivity information increases the turnover rate by mitigating the adverse selection problem. As a result, disclosure may enhance matching surplus but only at the cost of eroding a high-commitment environment. Hence, the firm faces a tradeoff between implicit incentive provisions and matching efficiency.

Indeed, firms adopt different channels of information transmission to influence the market's belief about its workers' productivity. Waldman (1984, 1990) discusses the role of promotion in signalling the worker's productivity to the outside market. A firm may also publicly announce the outcome of rank-order tournaments, where the winner is perceived as a highly skilled worker (Zábojník and Bernhardt, 2001; Koch and Peyrache, forthcoming). Another commonly used information channel is the extent of worker/client interaction.[3]

The purpose of this article is to formalize the role of disclosure in influencing the aforementioned tradeoff associated with turnover, and to draw out its implications for the firm's optimal disclosure policy.

I consider a model where an infinitely lived firm hires a sequence of short-lived agents. The agents differ in their productivity (high or low) or "types." The agents live for two periods. At the beginning of period 1, the type of agent is unknown to all parties (including the agent himself). In period 1, the agent exerts (unobservable) effort and produces an output (high or low) for the firm. Output is not contractible, and the firm offers bonus incentives sustained through implicit contracts. However, output completely reveals an agent's type, and it is observed by both the firm and the agent himself. In the second period, the agent works on a different task, where his productivity depends only on his type.

At the beginning of the game, the firm *commits* to a disclosure policy, that is, it decides whether to be transparent or opaque. A transparent firm shares all information about its agent's output with the outside labor market, but an opaque firm shares none. At the beginning of period 2, the outside labor market may attempt to raid the agent. The agent is assumed to be a better match with the raiders.[4] The firm decides whether to retain the agent by matching the raiders' offer, or to let him go. At the end of the second period of his life, the agent leaves the environment, and a new agent is hired. While leaving the firm, the old agent communicates the history of the game to the young. Thus, the agents perfectly observe the history of the game if there is no successful raid in the past. However, if the raid is successful in any period, the relevant history of the game prior to the raid is *not* observed by the subsequent generations of agents.

The reputation concerns of the firm, represented by its discount factor, say $\delta$, play a crucial role in governing its disclosure policy. There are two main findings. First, *optimal disclosure policy is either (i) transparency for all values of* $\delta$, *or (ii) opaqueness only for moderate values of* $\delta$*, and transparency otherwise*.

The intuition behind this result is as follows. Total profit of the firm from each generation of agents has two components: (i) profit in period 1 (which is increasing in effort until the first-best is reached) and (ii) the matching gains in period 2 that the firm can extract up front. Transparency maximizes matching gains but may induce lower effort by weakening the implicit contract. If matching gains are large, then the loss of effort under transparency is more than compensated by the matching gains in period 2. Hence, transparency becomes optimal for all $\delta$.

If the matching gains are not too large, opaqueness can be optimal for moderate $\delta$. For $\delta$ low enough, the effort induced by both transparency and opaqueness is sufficiently low. But the profit under transparency is higher due to higher matching gains. As $\delta$ increases, stronger implicit incentives under opaqueness may more than compensate for the lost matching surplus under transparency. However, if $\delta$ is sufficiently large, an opaque firm cannot credibly promise to retain an agent on the punishment path. When the future payoff is sufficiently lucrative, on the punishment path, an opaque firm might give up the static gains from retention (induced by adverse selection), and opt not to match the raiders' offer. By doing so, the firm expunges the history of defection and reverts back to the equilibrium course of play. Therefore, for high enough $\delta$, opaqueness does not facilitate incentive provisions (compared to the transparent case), but continues to yield lower matching gains by restraining turnover. Thus, transparency becomes optimal for $\delta$ sufficiently large.

[3] See Loveman and O'Connell (1996) for a case study on an information technology firm, HCL America, that contemplates whether to send engineers to client sites or to do the projects in-house so as to filter information by restricting client-worker interactions.

[4] This assumption is not crucial for the finding and it is made only for analytical simplicity. Section 5 discusses how this assumption can be relaxed to make the model more realistic.

My second result suggests that *among the firms that opt for opaqueness, firms that are more patient earn lower profits, once $\delta$ crosses a threshold. Moreover, the first-best effort level may not be feasible under opaqueness.*

Opaqueness is optimal only if it is sequentially rational for the firm to retain an agent even on the punishment path (as discussed above, if this is not the case then opaqueness is dominated by transparency). Now, consider a $\delta$ at which an opaque firm is indifferent between retaining and losing an agent on the punishment path. If the associated profit under opaqueness is sufficiently high compared to the transparent case, as $\delta$ increases, the firm might still prefer to remain opaque. But to do so, it must lower its incentive provisions in equilibrium, that is, settle for a lower profit. Otherwise, the temptation to revert back on the equilibrium path would be too large, and it will not be sequentially rational for the firm to retain the agent on the punishment path. Moreover, if the retention gains are moderate, a $\delta$ that creates enough reputation concern to support the first-best effort may be too high to ensure sequential rationality of offer matching on the punishment path.

The model also offers the following empirical implication: opaqueness becomes less likely to be the strictly optimal disclosure policy as the expected matching gains increase. The intuition behind this result is straightforward. The higher the expected matching gains are, the higher the opportunity cost of opaqueness is in terms of the foregone matching gains (that the firm extracts from the agent). Thus, opaqueness becomes relatively less profitable compared to transparency.

□ **Related literature.** This article contributes to the growing literature on optimal information disclosure in labor markets (Albano and Leaver, 2005; Bar-Isaac, Jewitt, and Leaver, 2008; Zábojník and Bernhardt, 2001; Koch and Peyrache, forthcoming; Mukherjee, 2008a, 2008b; Waldman, 1984, 1990), and it broadly relates to two strands of literature in personnel economics—implicit contracts and adverse selection in turnover.

Several authors have discussed the role of implicit contracts both as an incentive mechanism (Bull, 1987; MacLeod and Malcomson, 1989; Levin, 2003) and in defining the boundaries of a firm (Baker, Gibbons, and Murphy, 2001, 2002). These authors assume that the firm's ability to sustain an implicit contract is exogenously given. Levin (2002) offers a model that endogenizes the firm's ability to sustain implicit contracts. He considers a tradeoff that firms face between making commitments to a broad group of workers and making more limited commitments to individuals or smaller groups of employees. Broad commitments build trust and allow the firm to commit to stronger implicit incentives, but the firm loses flexibility in laying off workers should there be any changes in the economic environment. More recently, Board (2009) studies a model of implicit contracts that allows for on-the-job search and argues that stronger incentives are offered by firms with low turnover. However, none of these authors address the role of information disclosure in sustaining stronger implicit incentives. In contrast, Mukherjee (2008b) argues that when a firm attempts to augment the implicit incentives with the worker's career concerns, a firm's disclosure decision may affect its ability to sustain implicit contracts. This article is close to Mukherjee (2008b) in spirit, but in contrast it highlights the role of a firm's disclosure policy in sustaining implicit contracts through such a policy's impact on the firm's turnover rate.

Starting from the classic work by Greenwald (1986), the effects of adverse selection in turnover are also well studied in the literature (Acemoglu and Pischke, 1998; Gibbons and Katz, 1991; Lazear, 1986). Several authors have argued that asymmetric information among employers may lead to inefficient turnover and may also impact the incentive provisions inside the firm (see Gibbons and Waldman, 1999 for a survey on this topic). The novel part of my analysis is to show how a firm's disclosure policy can manipulate the adverse selection problem associated with turnover and, in turn, how it affects the firm's ability to offer implicit contracts.

The organization of the article is as follows. The next section develops a model that captures the tradeoff discussed above. Section 3 characterizes the optimal contracts under transparency and opaqueness. The optimal disclosure policy is characterized in Section 4. Section 5 discusses some of the key assumptions of my model. A final section concludes. Unless mentioned otherwise, all proofs are given in Appendix A.

## 2. The model

□ **A simple framework.** Before delving into the formal model, it is instructive to present a heuristic discussion of the modelling framework in order to illuminate the key tradeoff between inefficient turnover and stronger implicit contracts.[5]

Suppose a long-lived firm employs a sequence of short-lived workers. In each period, a worker can exert an effort $e \in \{0, 1\}$ in the task he has been assigned to. The firm prefers the worker to exert $e = 1$, but by exerting $e = 1$, the worker incurs a cost $c$. Effort is observable but not verifiable. Hence, the firm motivates the worker by promising a discretionary bonus payment, $B$, whenever $e = 1$. Thus, the workers would exert the effort only if $B \geq c$.

Let the per-period profit of the firm be $\pi$ when $e = 1$ and 0 when $e = 0$ . The workers play a trigger strategy where they continue to exert $e = 1$ if the firm has never reneged on its bonus promise in the past, but exert $e = 0$ if there has been a past deviation by the firm. Thus, the firm's bonus promise is credible as long as $\delta\pi/(1 - \delta) \geq B$. And the firm can sustain an implicit contract where the workers exert $e = 1$ if

$$\frac{\delta}{1-\delta}\pi \geq c. \tag{1}$$

Now suppose that the firm adopts a disclosure policy, namely transparency, that can increase workers' turnover. Assume that with probability $\alpha$ the old worker would leave the firm by the time a new worker arrives. Because the old worker does not get to communicate with the new worker, the new worker cannot observe whether the firm had ever reneged on its bonus promise. Hence, if the firm reneges on its promise, with probability $\alpha$, it will not be punished by the future generations of workers. In such a setting, the implicit contract is sustained only if the following condition holds[6]:

$$\frac{\delta(1-\alpha)}{1-\delta(1-\alpha)}\pi \geq c. \tag{2}$$

The cost of disclosure in terms of weaker implicit contracts is evident from a comparison of conditions (1) and (2). Note that disclosure, by resulting in higher turnover, reduces the effective discount factor of the firm by a factor of $(1 - \alpha)$. So, the implicit contracts are harder to sustain when there is high turnover. Weaker incentives reduce effort and, hence, profit decreases.

However, turnover can also enhance the firm's profit because the firm can extract the matching gains that the worker expects to earn in the future when they move to a better-matched employer. Hence, transparency is optimal if the matching gains from turnover outweigh the loss of profit due to weaker implicit incentives. This is the crux of the analysis that I will elaborate on in this article.[7]

□ **The formal model.** Although the aforementioned framework captures the key tradeoff, it purposefully abstracts from several key issues. First, effort may not be observable, giving rise to a moral hazard problem. Second, in a more general setting where effort level is not binary, the firm's per-period profit, $\pi$, can itself depend on the firm's discount factor $\delta$. Moreover, the relationship between $\delta$ and $\pi$ can be influenced by the firm's disclosure policy. Finally, one needs to explicitly model the channel (i.e., adverse selection in the labor market) through which disclosure affects turnover. In what follows, I present a formal model that incorporates these issues.

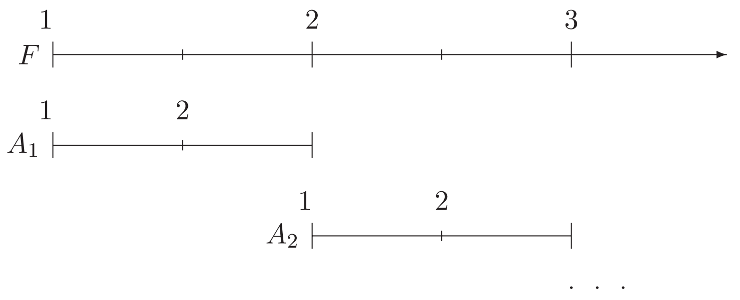
[5] I am indebted to an anonymous referee for suggesting this simplified exposition.

[6] I will elaborate on the derivation of this condition in Section 3.

[7] This framework also suggests that the key tradeoff with turnover continues to persist in a more general setting whenever lower turnover leads to any form of allocational inefficiency. I will further discuss this issue in Section 5.

FIGURE 1

THE TIME STRUCTURE OF THE GAME




*Players*. An infinitely lived firm, $F$, offers employment contracts to a sequence of short-lived agents. An agent in generation $t$, $A_t$, lives for two periods (see Figure 1).[8] If $A_t$ accepts $F$'s contract, he works for $F$ in period 1, but may get raided in period 2. In period 2 of each generation, two identical raiding firms, $R_1$ and $R_2$, appear with probability $\alpha$, and bid competitively for $A_t$.

**Stage game**. The stage game is the game played by each generation of agents with the firm and the raiders. The stage game has two periods, and it is defined in terms of its five key ingredients: *technology*, *disclosure policy*, *contracts*, *offer matching*, and the players' *payoffs*. We elaborate below on each of these five components.

*Technology*. Productivity of $A_t$ in period 1 depends on his type $\theta_i$, $i \in \{H, L\}$, which can be either high $(\theta_H)$ or low $(\theta_L)$. The type of $A_t$ is unknown to all players (including $A_t$ himself) at the beginning of the game, but it is known to follow a prior probability distribution $\Pr(\theta = \theta_H) = p$. In period 1, $A_t$ exerts effort $e \in [0, 1]$ to produce an output, $y$. The cost of effort $c(e) = \gamma e^2/2$, where $\gamma > 0$.[9]

The output depends on the type of agent as well as on his effort level. Let $y = \theta + z$, where $z \in \{0, 1\}$ and assume that $\theta_L + 1 \neq \theta_H$. Hence, the output completely reveals the agent's type.[10] The value of $z$ is stochastic, but is influenced by $e$. Let $\Pr(z = 1 \mid e) = e$. Output is observable but not verifiable. That is, $F$ cannot write a pay-per-performance contract based on $y$. Although $F$ and $A_t$ always observe $y$, the raiders observe $y$ only if $F$ discloses this information. I will elaborate on $F$'s disclosure policy shortly.

In period 2, $A_t$ works on a different task where his productivity depends only on his type. An agent with type $\theta_i$ produces an output level $\theta_i$ with $F$. The agent is always a better match with the raiders.[11] An agent with type $\theta_i$ produces an output $\theta_i + \mu$ with both raiders. I assume that $\mu > 0$ and its value is known to all players.

[8] I will denote the life span of an agent as a "generation" (indexed by $t$, $t = 1, 2, \ldots,$) and a unit length of time within a generation as a "period."

[9] The analysis of the key economic effects of disclosure does not hinge on the specific functional form. To highlight these effects, one can use cost function $c(e)$, such that $c(0) = c'(0) = 0$, $c' > 0$, $c'' > 0$, $c''' > 0$. However, the characterization of the optimal disclosure policy is analytically more tractable with an exact functional form of the cost function.

[10] This assumption is not essential for my findings to hold. In fact, if the output does not completely reveal the agents' type, the agents may have "career concern" incentives (see Mukherjee, 2008a). I abstract away from this possibility in order to focus on the implicit contracts as the only source of incentives in the model.

[11] This assumption is made only for analytical simplicity and is not essential for the main results to hold. I will further elaborate on this issue in Section 5.

*Disclosure policy*. Disclosure policy, $d$, is a binary choice between *opaqueness* and *transparency* that $F$ makes at the beginning of the game.[12] When $F$ is transparent, the raiders observe the output $y$ produced by the current generation of agents. In contrast, when $F$ is opaque, no information about $y$ is available to the raiders. Disclosure policy does not affect the observability of history for any player. In other words, I only consider the disclosure decision of the firm that affects the firm's transparency with respect to the outside labor market. The firm's opacity with respect to the outside labor market need not imply opacity with respect to the inside workers. Because the agents are "insiders" in the firm, one may assume that they have access to the records (i.e., the verifiable or hard information) of the firm's past behavior that the outsiders do not. Moreover, as I will elaborate below, the agents may also learn the soft information about the firm's past behavior from communicating with their predecessors. Such an information channel is not accessible to the outside labor market.

*Assumption 1*. $F$'s disclosure decision is irreversible.

Once chosen, it is prohibitively costly to change the level of transparency at a future date. This assumption strengthens the tradeoff between the sustenance of implicit contracts and the extraction of matching gains. Even if $F$ chooses to be opaque and sacrifice the matching efficiency, as will be made clearer later, $F$ might have an incentive to become transparent following a defection on the implicit contract. Assumption 1 rules out this possibility.[13]

The tradeoff, however, exists as long as the firm bears a cost to revert its disclosure policy. Assumption 1 states that this cost is prohibitively high. This assumption is, therefore, more restrictive than what is needed to substantiate the tradeoff. But I will maintain this assumption because it simplifies the exposition without sacrificing any major insights of the model.

*Contracts*. Because $y$ is not contractible, $F$ can only commit to a lump-sum wage $w_1$ in period 1. But $F$ can motivate $A_t$ to exert effort by offering an implicit contract that promises a bonus payment $B$ if $z = 1$. Such a contract is sustained by the threat of retaliation by future generations of workers if the firm reneges on its bonus promise.

Because the period 2 output does not depend on effort, incentive contracts are redundant. $F$ only offers a lump-sum wage $w_2$ in period 2.

*Offer matching*. If the raiders $R_1$ and $R_2$ are present, they bid $\beta_1$ and $\beta_2$, respectively, for $A_t$, given the available information on the agent's type (bids are assumed to be simultaneous). $F$ makes the period 2 wage offer, $w_2$, after observing the raiders' bids. Thus, in this case, $w_2$ can be interpreted as a counteroffer of $F$ to $A_t$. $A_t$ chooses the highest bidder as his future employer. In case of a tie, he stays with $F$. If the raiders are not present, $A_t$ works for $F$ at the wage $w_2$ (if $A_t$ accepts $F$'s offer).

*Payoffs*. The expected payoff of $A_t$, $U_t$, is the sum of his expected payoffs in the two periods of his life, that is, $U_t = u_1^t + u_2^t$, where $u_\tau^t$ is the expected payoff in period $\tau = 1, 2$. Given the level of effort $e$, the expected payoff of $A_t$ in period 1 is simply equal to the expected transfer from $F$ net the cost of effort. Thus, $u_1^t(e) = eB + w_1 - c(e)$.

In period 2 of his life, $A_t$'s expected payoff depends on his choice of employer. Therefore, $u_2^t$ can be written as

$$u_2^t = \begin{cases} \mathbb{E}\max\{\beta_1, \beta_2, w_2\} & \text{if raiders appear} \\ w_2 & \text{otherwise.} \end{cases}$$

In both periods, $A_t$ can reject all contracts and earn a reservation payoff of 0.

[12] For example, one can think of the disclosure decision as the firm's decision whether to allow client contact (i.e., be transparent) or not (i.e., be opaque).

[13] If one interprets disclosure decision as a part of job design, this assumption suggests that once a firm adopts a specific job design, it is costly to change it in the future.

The expected payoff of $F$ in generation $t$, $\pi_t$, is the total expected profit $F$ earns over the two periods, that is, $\pi_t = \pi_1^t + \pi_2^t$, where $\pi_\tau^t$ is the profit in period $\tau = 1, 2$. The period 1 profit of $F$ for a given effort level is $\pi_1^t(e) = (\bar{\theta} + e) - w_1 - eB$, where $\bar{\theta} = \mathbb{E}(\theta)$. In period 2, $F$ can earn positive profit only if it is successful in retaining the agent. So,

$$\pi_2^t = \begin{cases} \bar{\theta} - w_2 & \text{if } A_t \text{ stays with } F \\ 0 & \text{otherwise.} \end{cases}$$

It is implicit in this specification that both $F$ and $A_t$ are risk neutral and that they do not discount the future in the stage game.

*Time line*. The timing in the stage game is as follows.

*Period 1.0.* $F$ offers a contract $(w_1, B)$ to $A_t$. If accepted, the game goes to period 1.1; the game ends otherwise.

*Period 1.1.* $A_t$ exerts effort $e$.

End of period 1. Output $y$ is realized. $R_1$ and $R_2$, if present, observe $y$ when $F$ is transparent.

*Period 2.0.* If $R_1$ and $R_2$ do not appear, $F$ offers $w_2$ to $A_t$, and the game directly goes to the end of period 2. If $R_1$ and $R_2$ are present, they bid for $A_t$ and offer $\beta_1$ and $\beta_2$, respectively. The game goes to period 2.1.

*Period 2.1.* $F$ makes a wage offer (counteroffer) $w_2$ to $A_t$ after observing $\beta_1$ and $\beta_2$.

*Period 2.2.* $A_t$ chooses which employment contract to accept.

End of period 2. Period 2 wages are paid; the stage game ends.

**Repeated game**. The stage game played between the firm and each generation of agents is repeated in every generation. The firm discounts its profits from future generations at the rate $\delta \in [0, 1)$.

*History of the game*. The history of the game at the beginning of generation $t$ is $\{h_\tau\}_{\tau=1}^{t-1}$, where $h_\tau$ is the history of play in the $\tau$th stage game (or generation). The stage game history, $h_\tau$, is a tuple that reports the following: (i) the choice of the disclosure policy of the firm, $d$, (ii) the contract offered at the beginning of the stage game $\{w_1\}_\tau$, (iii) $A_\tau$'s decision on whether to accept the contract, $x_\tau \in \{accept, reject\}$, (iii) the output in period 1 ($y_\tau$) and $F$'s actual bonus payment, $\tilde{B}_\tau$, (iv) raiders' bids (if they are present) and $F$'s wage offer in period 2, $\{\beta_1, \beta_2, w_2\}_\tau$, and, finally, (v) $A_\tau$'s choice of period 2 employer, $z_\tau \in \{F, R_1, R_2\}$. That is, $h_\tau = (d, \{w_1\}_\tau, x_t, \{y, \tilde{B}\}_\tau,$ $\{\beta_1, \beta_2, w_2\}_\tau, z_\tau)$.

In any generation $t$, $F$ always observes the entire history of the game. However, $A_t$ may not have a perfect observation of history. Denote $h_\tau^{-y} = (d, \{w_1\}_\tau, x_t, \tilde{B}_\tau, \{\beta_1, \beta_2, w_2\}_\tau, z_\tau)$, that is, the vector $h_\tau^{-y}$ is obtained from the vector $h_\tau$ by omitting the value of $y$. Let $A_k$, $k \in \{0, 1, \ldots, t-1\}$, be the *last* generation of agents before $A_t$ who was separated from $F$ ($k = 0$ represents no separation in the history of the game). I assume the following on $A_t$'s observability of the history:

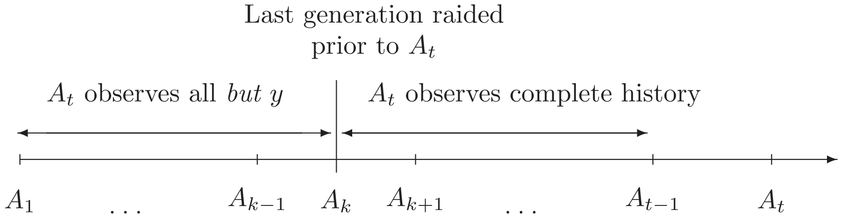
*Assumption 2*. $A_t$ observes the history $\{h_\tau^{-y}\}_{\tau=1}^{k} \cup \{h_\tau\}_{\tau=k+1}^{t-1}$.

Assumption 2 states two things: (i) if any generation of agents, say $A_k$, is separated from $F$, the history of output, $y$, produced by all generations up to $k$, is not observed by $A_t$ $(t > k)$, and (ii) $A_t$ perfectly observes all other components of the history (Figure 2).

This assumption can be motivated as follows. Suppose $y$ is soft information, in the sense that $A_t$ cannot *directly* observe the output produced by the past generation of agents. However, $A_t$ can learn about the past output from his predecessor generation, $A_{t-1}$. Before leaving $F$ at period 2 of his life, $A_{t-1}$ communicates his observed history of the game to $A_t$. Thus, $A_t$ cannot learn the output produced by past generations if $A_{t-1}$ is not employed with $F$ in period 2 of his life. $A_t$ can perfectly observe all other components of the history because they are hard information and

FIGURE 2

$A_t$'S OBSERVABILITY OF THE GAME'S HISTORY




can be directly observed.[14] As I will discuss later, Assumption 2 has major implications for the punishment payoff of the firm.

I assume that the raiders also do not observe the complete history of the game but observe the same history as observed by the agent they attempt to poach.[15]

*Strategies and equilibrium.* Due to their analytical tractability, I will focus attention only on pure strategies. A pure strategy of the firm has two components. First, at the beginning of the game, $F$ decides its disclosure policy, that is, whether to be transparent or opaque. Second, in every generation, $F$ again takes three decisions. First, depending on the history of the game, $F$ offers to each new agent a wage $w_1$ at the beginning of period 1. Second, at the end of period 1, $F$ makes a discretionary bonus payment $\tilde{B}$ depending on the history of the game, contracted wage $w_1$, and the period 1 output $y$. And finally, at the beginning of period 2, $F$ decides on the period 2 wage offer ($w_2$) given the history of the game and the raiders' offers (if present).

The strategy of the agent, $A_t$ also has two components. At the beginning of each generation, $A_t$ decides on his effort level, given the history of the game and the contract offered by the firm. Also, at the end of period 1, if raiders are present, $A_t$ chooses which employment contract to accept (if any) given the history of the game and the raiders' offers.

Finally, the strategy of a raider $R_j$ $(j = 1, 2)$, $\beta_j$, is simply a wage bid given the information available to him.

I consider *perfect Bayesian equilibrium in trigger strategies* as a solution concept. $A_t$ triggers punishment if $F$ has *reneged* on its bonus promise to any agent starting from generation $k + 1$ *and/or* $A_k$ has *rejected* $F$'s contract. ($F$ is said to have reneged on its bonus promise if the actual bonus payment $\tilde{B}_\tau$ is different from the promised bonus amount $B_\tau$.)

Assumption 2, combined with the trigger strategy played by the agents, has two major implications for the punishment payoff of $F$. First, if an agent is raided in the punishment phase of the game, the equilibrium play resumes from the next generation. Second, although $F$ can expunge the history of defection by simply not hiring a generation of agents in the punishment phase, $F$ cannot revert to equilibrium play by doing so. That is, the punishment phase terminates *only* if there is a successful raid.

## 3. The optimal contracts under transparency and opaqueness

■ I will start my analysis by discussing the first-best effort level, $e^{FB}$, that maximizes the joint profit between $F$ and $A_t$ in a given generation. Because period 2 payoffs of both $F$ and $A_t$ do not

[14] The assumption that turnover completely deletes parts of the game's history is adopted only for analytical simplicity. It is not essential for the key results to hold, and one can assume a more realistic setting where turnover simply delays the information transmission across generations rather than completely blocking it. Section 5 discusses this issue in more detail.

[15] Alternative specifications regarding the observability of history by the raiders can be assumed without affecting the key findings. However, the analysis becomes considerably streamlined if one assumes that the raiders can observe when the game is on the punishment path. The specification I assume here ensures that this is indeed the case.

depend on $e$, $e^{FB} = \arg\max_e \mathbb{E}(\theta + z \mid e) - c(e) = \arg\max_e e - c(e)$. Hence, $e^{FB}$ can be defined by the associated first-order condition given as follows:

$$1 = c'(e^{FB}) = \gamma e^{FB}.$$

The first-best level of effort offers a benchmark to compare and contrast the maximal effort level that $F$ can induce $A_t$ to exert under opaqueness and transparency.

The optimal disclosure policy for a given $\delta$ is the one that induces the highest per-generation profits to $F$. Thus, to characterize the optimal disclosure policy, it is essential to characterize the optimal contracts under opaqueness and transparency. In what follows, I will restrict attention to the class of stationary contracts (i.e., in equilibrium, $F$ offers the same contract $(w_1, B, w_2)$ to every generation). This is without loss of generality, because if an optimal contract exists, there are stationary contracts that are payoff equivalent to the optimal contract (see Levin, 2003).

□ **Optimal contract in a transparent firm.** Under transparency, both the firm and the raiders (if present) observe the agent's type. Because the raiders compete to hire the agent, they bid the full value of the agent. That is, under transparency, for $j = 1, 2$,

$$\beta_j = \theta_i + \mu, \quad \text{for } i = H, L.$$

It is never optimal for $F$ to match the raider's offer, and all types of agents leave $F$ to join the raiding firms. Thus, if the raiders are present, $F$ earns 0 in period 2. However, if the raiders do not appear (an event that occurs with probability $1 - \alpha$), $F$ earns an expected period 2 profit of $\bar{\theta} - w_2$ by retaining the agent. Using this observation, the equilibrium expected per-generation profit of $F$ (for a given level of effort) can be written as

$$\pi_t^T(e) = (\bar{\theta} + e) - w_1 - eB + (1 - \alpha)(\bar{\theta} - w_2). \tag{3}$$

(The superscript $T$ in $\pi_t^T$ refers to the transparent case.) The optimal contract maximizes (3) by choosing $w_1$, $B$, and $w_2$, but it must satisfy the individual rationality (*IR*) and incentive compatibility ($IC$) constraints. The (*IR*) constraint requires that if $A_t$ is to accept $F$'s contract, in each period $F$ must offer $A_t$ an expected payoff that is at least as large as his reservation payoff (i.e., 0). The ($IC$) constraint ensures that $A_t$ chooses his effort level optimally, given the contract offered by $F$. Moreover, because the bonus promise ($B$) is sustained through reputation, the optimal contract must also satisfy a dynamic restriction constraint (*DR*). The (*DR*) constraint requires that $F$'s punishment payoff from reneging on its bonus promise is (weakly) less than its equilibrium payoff. Let the continuation value of a transparent firm's payoff in the equilibrium path and the punishment path be $\overline{\Pi}^T$ and $\underline{\Pi}^T$, respectively. Also note that if the firm cheats on generation $t$, the transparent firm's offer-matching behavior in period 2 of generation $t$ is the same as its behavior on the equilibrium path (in both cases, the firm earns $(1 - \alpha)(\theta_i - w_2)$ in period 2 of generation $t$, where $\theta_i$ is the type of worker in generation $t$). So, the (*DR*) constraint requires $(1 - \alpha)(\theta_i - w_2) + \delta\overline{\Pi}^T \geq B + (1 - \alpha)(\theta_i - w_2) + \delta\underline{\Pi}^T$, or $\delta\overline{\Pi}^T \geq B + \delta\underline{\Pi}^T$. Thus, the optimal contract under transparency must solve the following program:

$$\max_{w_1, B, w_2} \pi_t^T(e) = (\bar{\theta} + e) - w_1 - eB + (1 - \alpha)(\bar{\theta} - w_2)$$

$$s.t. \begin{cases} w_1 + eB - c(e) + \alpha(\bar{\theta} + \mu) + (1 - \alpha)w_2 \geq 0 \text{ and } w_2 \geq 0 & (IR) \\ e \in \arg\max_{e'} e'B - c(e') & (IC) \\ \delta\overline{\Pi}^T \geq B + \delta\underline{\Pi}^T. & (DR) \end{cases}$$

It is straightforward to argue that (*IR*) must bind at the optimal contract (else, $F$ can lower $w_1$ to increase profit) and, without loss of generality, one can set $w_2 = 0$. Moreover, given the convexity of $c(e)$, the ($IC$) constraint can be written as $B = c'(e)$. Now, using the (*IR*) and ($IC$)

constraints to eliminate $w_1$ and $B$, the optimal contracting problem can be written as

$$\max_e e - c(e) + \alpha\mu + 2\bar{\theta}$$
$$s.t.\ \delta\overline{\Pi}^T \geq c'(e) + \delta\underline{\Pi}^T. \quad (DR)$$

By definition, $\overline{\Pi}^T = \pi_t^T/(1-\delta)$. In order to characterize the optimal contract, it is also essential to compute $\underline{\Pi}^T$. Suppose $F$ reneges on its bonus promise to $A_t$. If $A_t$ is raided, which occurs with probability $\alpha$, agents in generation $t+1$ onward will not observe the output produced by generation $t$ and will not trigger the punishment. Therefore, in generation $t+1$, the continuation value of $F$'s payoff stream (starting from generation $t+1$ onward) is simply equal to the equilibrium continuation value $\overline{\Pi}^T$. But if $A_t$ is not raided, $A_{t+1}$ observes the deviation and triggers the punishment. Under punishment path $e = 0$, therefore, $F$ earns the resulting joint surplus between $F$ and $A_t$, that is, $\alpha\mu + 2\bar{\theta}$. Moreover, the continuation value of the punishment payoff realized from generation $t+2$ onward has a discounted value of $\delta\underline{\Pi}^T$ in generation $t+1$. Therefore, if $A_t$ is not raided, the punishment payoff of $F$ starting from generation $t+1$ is $\left(\alpha\mu + 2\bar{\theta}\right) + \delta\underline{\Pi}^T$. So, one can write

$$\underline{\Pi}^T = \alpha\overline{\Pi}^T + (1-\alpha)[(\alpha\mu + 2\bar{\theta}) + \delta\underline{\Pi}^T],$$

or,

$$\underline{\Pi}^T = \frac{1}{1-\delta(1-\alpha)}[\alpha\overline{\Pi}^T + (1-\alpha)(\alpha\mu + 2\bar{\theta})]. \tag{4}$$

By plugging in the values of $\overline{\Pi}^T$ and $\underline{\Pi}^T$, the optimal contracting problem can be written as

$$\mathcal{P}^T : \begin{cases} \max_e \pi^T(e) = e - c(e) + \alpha\mu + 2\bar{\theta} \\ s.t.\ \delta(1-\alpha)\,[e - c(e)]\,/\,(1-\delta(1-\alpha)) \geq c'(e). \qquad (DR^T) \end{cases}$$

Let $e^T(\delta)$ be the solution to the program $\mathcal{P}^T$ for a given $\delta$ and $\Pi^T(\delta)$ be the associated value, that is, $\Pi^T(\delta) = e^T(\delta) - c(e^T(\delta)) + \alpha\mu$. The following lemma characterizes $\Pi^T(\delta)$.

*Lemma 1*. There exist values of $\delta$, $\underline{\delta}^T$, and $\overline{\delta}^T$, and functions $\hat{\Pi}^T : [0, 1) \to \mathbb{R}$ and $\hat{e}^T(\delta) : (0, 1] \to \mathbb{R}_+$, such that

$$\Pi^T(\delta) = \begin{cases} \alpha\mu + 2\bar{\theta} & \text{if } \delta \leq \underline{\delta}^T \\ \hat{\Pi}^T(\delta) & \text{if } \underline{\delta}^T < \delta < \overline{\delta}^T \\ e^{FB} - c\left(e^{FB}\right) + \alpha\mu + 2\bar{\theta} & \text{if } \delta \geq \overline{\delta}^T, \end{cases}$$

and

$$e^T(\delta) = \begin{cases} 0 & \text{if } \delta \leq \underline{\delta}^T \\ \hat{e}^T(\delta) & \text{if } \underline{\delta}^T < \delta < \overline{\delta}^T \\ e^{FB} & \text{if } \delta \geq \overline{\delta}^T. \end{cases}$$

Moreover, $\Pi^T(\delta)$ and $e^T(\delta)$ are continuous and (weakly) increasing.

The intuition behind this result is as follows. For $\delta$ below a certain threshold, $\underline{\delta}^T$, $(DR^T)$ is always binding and the firm cannot credibly commit to any bonus payment. The firm can only sustain the minimal effort level 0 and, therefore, it only earns a profit of $\alpha\mu + 2\bar{\theta}$. As $\delta$ increases above $\underline{\delta}^T$, the left-hand side of $(DR^T)$ increases for any given $e$ and relaxes the $(DR^T)$ constraint. Thus, the largest value of $e$ that satisfies $(DR^T)$ also increases. Consequently, the associated profit increases as well. This is represented by the function $\hat{\Pi}^T(\delta)$. As $\delta$ exceeds a threshold, $\overline{\delta}^T$, the first-best effort becomes feasible.

□ **Optimal contract in an opaque firm.** The analysis of the optimal contract in an opaque firm is similar to its transparent counterpart with one major exception. Because the raiders do not observe the output under opaqueness, they may face an adverse selection problem when bidding for the agent. Assumption 3 ensures that this is indeed the case.

*Assumption 3.* $\bar{\theta} + \mu < \theta_H$.

Under Assumption 3, by bidding the average productivity of the agent, the raiders will necessarily overbid for him. Because $F$ observes the type of agent, $F$ will always match the offer for a $\theta_H$-type agent, and only a $\theta_L$-type agent will leave $F$ and join the raiders. Therefore, under opaqueness, the raiders will only bid for the $\theta_L$-type agent, that is, for $j = 1, 2$,

$$\beta_j = \theta_L + \mu.$$

This is the standard market failure argument under adverse selection (Akerlof, 1970). When the raiders are present, the adverse selection problem allows $F$ to retain a $\theta_H$-type agent (drawn with probability $p$) at the wage $\theta_L + \mu$, and $F$ earns a retention profit of $\theta_H - \theta_L - \mu$. Thus, similar to equation (3), the period 2 expected profit of $F$ in generation $t$ can be written as

$$\pi_t^O = (\bar{\theta} + e) - w_1 - eB + \alpha p(\theta_H - \theta_L - \mu) + (1 - \alpha)(\bar{\theta} - w_2). \tag{5}$$

(The superscript $O$ in $\pi_t^O$ refers to the opaque case.) Analogous to the transparent case, the optimal contract under opaqueness maximizes (5) by choosing $w_1$, $B$, and $w_2$. But in contrast with its transparent counterpart, the optimal contract must satisfy an additional constraint. Not only must it satisfy the (*IR*), $(IC)$, and (*DR*) constraints but it also must satisfy a sequential rationality $(SR)$ constraint on the firm's offer-matching behavior. The nature of the $(SR)$ constraint is explained below.

Although it is always optimal for an opaque firm on equilibrium to retain the high-type agent, this need not be the case on the punishment path. Recall that if an agent in generation $t$ leaves the firm in period 2 of his life, the complete history of the game up to generation $t$ is not observed by later generations of agents. Therefore, a defecting firm faces punishment only until the first turnover occurs following the defection. To expedite turnover, an opaque firm may opt to forego the static gains from retention in order to revert to the equilibrium payoff from the immediate next generation.

However, if opacity is optimal in equilibrium, it is crucial that the firm retains the high-type agent even on the punishment path. A brief argument is as follows: the benefit for opacity over transparency stems from the fact that opacity induces lower turnover due to adverse selection and, hence, allows the firm to credibly promise a stronger incentive. But if the firm never retains the agent on the punishment path, it induces the same turnover rate as obtained under transparency. Consequently, the incentive benefits of opacity disappear but the firm continues to incur its cost in terms of inefficient matching. A detailed analysis of the case where the firm does not retain the agent on the punishment path is presented in Appendix B. As elaborated in Appendix B, the above argument ensures that the firm's payoff under transparency must dominate its payoff under opacity with no retention on the punishment path unless $\gamma$ is too small. When $\gamma$ is too small there is a secondary effect (stemming from the retention gains in the current period) that makes the analysis more involved. Because this effect is not central to the tradeoff that we are interested in, to keep the analysis simple, we rule out this effect by assuming that $\gamma$ is not too small. A sufficient condition for the above to hold is $\gamma \geq 1/2\,(1 + \alpha)\,p\mu$. We will maintain this assumption throughout our analysis.

□ In light of this observation, I will focus on the case where the firm retains the high-type agent on the punishment path. Let $\overline{\Pi}^O$ be the continuation values of an opaque firm's payoff on the equilibrium path. Also denote $\underline{\Pi}^O$ as the continuation values of an opaque firm's punishment payoff when the firm matches the raiders' bids and retains the $\theta_H$-type agent in period 2. Similar to the transparent case, one can derive $\overline{\Pi}^O = \pi_t^O/(1-\delta)$, and

$$\underline{\Pi}^O = \frac{1}{1-\delta(1-\alpha(1-p))}[\alpha(1-p)\overline{\Pi}^O + (1-\alpha(1-p))(\alpha(1-p)\mu + 2\bar{\theta})]. \tag{6}$$

Observe that the term $\alpha(1-p)$ in equation (6) represents the probability of a successful raid in a given generation, conditional on the offer-matching behavior of the firm on the punishment path (if $F$ matches the raiders' offers on the punishment path, only the $\theta_L$-type agent (drawn with probability $(1-p)$) is raided).

Now, the optimal contract of an opaque firm that retains the $\theta_H$-type agent on the punishment path must satisfy the following sequential rationality constraint:

$$\delta\overline{\Pi}^O \leq (\theta_H - \theta_L - \mu) + \delta\underline{\Pi}^O. \tag{SR}$$

The $(SR)$ constraint requires that the firm's payoff from retaining the $\theta_H$-type agent $((\theta_H - \theta_L - \mu) + \delta\underline{\Pi}^O)$ must be at least as large as its payoff from the reversion to equilibrium play starting from the immediate next generation $(\delta\overline{\Pi}^O)$.

Next, I will characterize the optimal contract in an opaque firm that retains a $\theta_H$-type agent on the punishment path. By plugging in the values of $\overline{\Pi}^O$ and $\underline{\Pi}^O$ and using $(IC)$ and $(IR)$ constraints to eliminate $w_1$, $B$, and $w_2$, one can write the optimal contracting problem as follows:

$$\mathcal{P}^O : \begin{cases} \max_e e - c(e) + \alpha(1-p)\mu + 2\bar{\theta} & \\ s.t. \quad \delta(1-\alpha(1-p))[e - c(e)]/(1-\delta(1-\alpha(1-p))) \geq c'(e), & (DR^O) \\ \delta(1-\alpha(1-p))[e - c(e)]/(1-\delta(1-\alpha(1-p))) \leq \theta_H - \theta_L - \mu. & (SR) \end{cases}$$

The following lemma makes an important observation on $\mathcal{P}^O$.

*Lemma 2*. For $\delta$ sufficiently high, $e^{FB}$ is not feasible in $\mathcal{P}^O$. Moreover, if $\theta_H - \theta_L - \mu < c'(e^{FB})$, $e^{FB}$ is not feasible for any $\delta$.

Lemma 2 suggests that if retention profits $(\theta_H - \theta_L - \mu)$ are relatively small compared to the marginal cost of effort at the first-best level, the first-best effort level is not feasible under $\mathcal{P}^O$. To keep the exposition simple, I will maintain this assumption throughout the rest of this analysis.

*Assumption 4*. $\theta_H - \theta_L - \mu < c'(e^{FB})$.

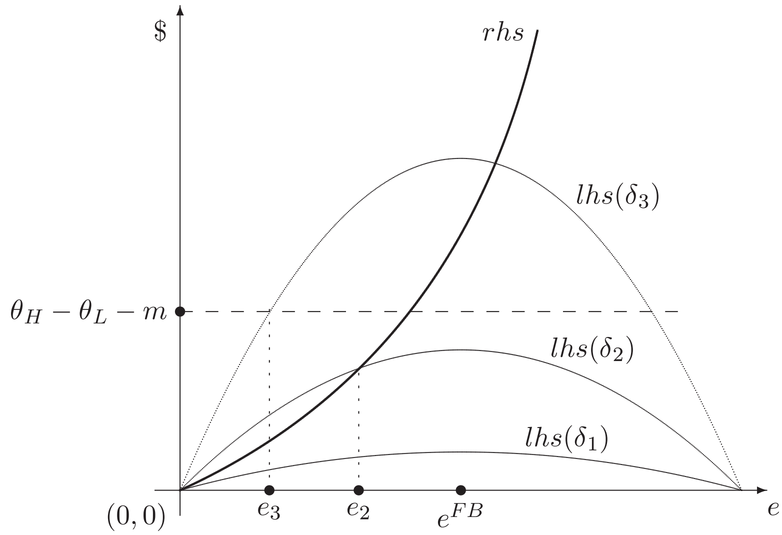
Let $e^O(\delta)$ be the solution to the program $\mathcal{P}^O$ for a given $\delta$, and $\Pi^O(\delta)$ be the associated value. The nature of $e^O(\delta)$ can be best explained with the help of Figure 3.

Figure 3 plots the right- and left-hand sides of $(DR^O)$ as a function of $\delta$. For $\delta$ sufficiently low, say $\delta_1$, $(DR^O)$ is always binding, and $F$ cannot motivate the agent to exert any effort. Therefore, $F$ only earns the joint surplus between $F$ and $A_t$ at $e = 0$, that is, $\Pi^O = \alpha(1-p)\mu + 2\bar{\theta}$. The $(DR^O)$ constraint holds with equality at $e = 0$ , but the $(SR)$ constraint is slack. Once $\delta$ crosses a threshold, say $\underline{\delta}^O$, the $(DR^O)$ constraint relaxes and $F$ can credibly commit to a bonus payment to motivate the agent to exert effort. As long as $(SR)$ is slack, $e^O(\delta)$ is simply the maximal value of $e$ at which $(DR^O)$ binds with equality. Consequently, $e^O(\delta)$ increases with $\delta$ and so does $\Pi^O(\delta)$. This is the case with $\delta = \delta_2$ in Figure 3. At $\delta = \delta_2$, $e^O(\delta) = e_2$, that is, the value of $e$ at which $(DR^O)$ binds. However, $e^O(\delta)$ is not monotonically increasing in $\delta$. Once $\delta$ becomes sufficiently large and crosses a threshold, say $\delta^*$, $(SR)$ becomes binding. This is the case with $\delta_3$ in Figure 3. Although $e_2$ does not violate $(DR^O)$ at $\delta = \delta_3$, the firm must settle for a lower effort level $e_3$ to satisfy $(SR)$. Thus, $\Pi^O(\delta)$ starts to decrease with $\delta$.

The following lemma summarizes the discussion above. (I omit the formal proof as the basic argument is already presented above.)

FIGURE 3

THE PLOT OF THE ($DR^O$) CONSTRAINT FOR DIFFERENT $\delta(\delta_3 > \delta_2 > \delta_1)$ AND THE OPTIMAL EFFORT ($e_i = e^O(\delta_i)$)




*Lemma 3*. There exist values of $\delta$, $\underline{\delta}^O$, and functions $\hat{\Pi}^O : [0, 1) \to \mathbb{R}$ and $\hat{e}^O : [0, 1) \to \mathbb{R}_+$ such that

$$\Pi^O(\delta) = \begin{cases} \alpha(1-p)\mu + 2\bar{\theta} & \text{if } \delta \leq \underline{\delta}^O \\ \hat{\Pi}^O(\delta) & \text{otherwise,} \end{cases}$$

and

$$e^O(\delta) = \begin{cases} 0 & \text{if } \delta \leq \underline{\delta}^O \\ \hat{e}^O(\delta) & \text{otherwise.} \end{cases}$$

Moreover, $\Pi^O(\delta)$ and $e^O(\delta)$ are continuous and there exists a value of $\delta$, $\delta^* > \underline{\delta}^O$, such that $\Pi^O(\delta)$ and $e^O(\delta)$ are (weakly) increasing for $\delta \leq \delta^*$ and decreasing otherwise.

Lemma 3 illustrates a key tradeoff implied by the ($SR$) constraint. As $\delta$ becomes sufficiently large, on the punishment path, the gains in $F$'s profit from reversion to equilibrium are too lucrative. Thus, if $F$ must credibly promise to pay the bonus and must always find it sequentially rational to retain the $\theta_H$-type agent on the punishment path, it must settle for a smaller equilibrium payoff when $\delta$ increases beyond a sufficiently high threshold.

The results developed in this section are instructive in characterizing the optimal disclosure policy of the firm. This issue is discussed in the following section.

## 4. The optimal disclosure policy

■ For a given $\delta$, the optimal disclosure policy of a firm is the one that yields the highest per-generation profit. Hence, for any $\delta$, opacity is (strictly) optimal if and only if $\Pi^O(\delta) > \Pi^T(\delta)$.[16] The following proposition characterizes the optimal disclosure policy of the firm.

[16] Recall that in our model the firm's payoff from transparency always dominates its payoff from opacity if the firm never retains the agent on the punishment path (see Appendix B for details).

*Proposition 1*. The optimal disclosure policy must be one of the following: (i) transparency is optimal for all $\delta$, or (ii) there exist two values of $\delta$, say $\underline{\delta}$ and $\overline{\delta}$, such that opaqueness is optimal only if $\delta \in (\underline{\delta}, \overline{\delta})$, and transparency is optimal otherwise.

The intuition behind this result is as follows. The total profit of $F$ under both transparency and opaqueness consists of the profits in period 1 (increasing in effort until the first best is reached) and the matching gains in period 2 (that $F$ can extract up front). Recall that the tradeoff with transparency is that it maximizes the matching gains but induces lower effort by weakening the implicit contracts. If the matching gains are large, then the loss of effort under transparency in period 1 is more than compensated by the matching gains in period 2. In such a situation, transparency is optimal for all $\delta$.

However, opacity can be optimal for moderate $\delta$ if the matching gains are not too large. I have already argued that for $\delta$ sufficiently low, the firm cannot induce any effort under both transparency and opaqueness. For all such values of $\delta$, transparency is optimal because it maximizes the matching gains.

As $\delta$ increases, the firm can offer effort incentives under both transparency and opaqueness. Now, the minimum $\delta$ at which an opaque firm can offer any effort incentive ($\underline{\delta}^O$) is less than the minimum $\delta$ at which a transparent firm can offer any effort incentive ($\underline{\delta}^T$) (again, the reason can be traced back to the fact that the (*DR*) constraint is tighter under transparency). Thus, for all $\delta$ in $(0, \underline{\delta}^T)$, the profit in a transparent firm stays constant, whereas the profit in an opaque firm increases. If the initial difference between the profits under transparency and opaqueness is not too large (which is the case when matching gains are moderate), profit under opaqueness catches up with the profit under transparency. That is, there exists a $\delta$, say $\underline{\delta}$, such that transparency dominates opacity for all values of $\delta$ to the left of $\underline{\delta}$, and opaqueness is optimal for all values of $\delta$ to the right of $\underline{\delta}$.

However, there are two reasons why opaqueness cannot be optimal for all $\delta > \underline{\delta}$. First, with quadratic cost function, effort as a function of $\delta$ may rise at a slower rate under opaqueness than under transparency, as long as $(SR)$ is nonbinding. So, as $\delta$ increases, the incentive advantage under opaqueness can get muted. By virtue of the additional matching gains, transparency may again prevail over opaqueness as the optimal disclosure policy. Second, once $\delta$ becomes sufficiently large, $(SR)$ becomes binding, that is, it is no longer sequentially rational for an opaque firm to retain an agent on the punishment path. When the value of the equilibrium payoff ($\Pi^O$) is sufficiently high compared to that in the punishment phase ($\underline{\Pi}^O$), an opaque firm might give up the static gains from retention (induced by adverse selection) and opt not to match the raiders' offer on the punishment path. By doing so, the firm expunges the history of defection and reverts back to the equilibrium payoff. Thus, for high enough $\delta$, opaqueness gives no advantage in terms of incentive provision (compared to the transparent case), but continues to yield lower matching gains in equilibrium. Consequently, transparency becomes optimal.

Figure 4 plots the maximal profits associated with the transparent and opaque cases as a function of $\delta(\Pi^T(\delta)$ and $\Pi^O(\delta))$, and it depicts a case where opaqueness is optimal for firms with moderate values of $\delta$ (case (ii) in Proposition 1).

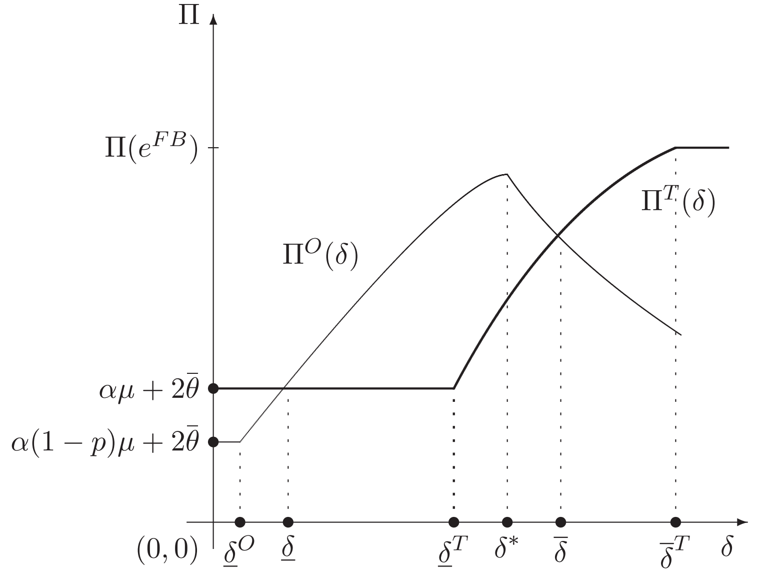
Lemmas 2 and 3 are also instructive in characterizing an opaque firm's payoff in equilibrium.

*Proposition 2*. Suppose opaqueness is (strictly) optimal for all $\delta \in (\underline{\delta}, \overline{\delta})$. Then, depending on parameter values, there may exist a $\delta^* \in (\underline{\delta}, \overline{\delta})$ such that for all $\delta \in (\delta^*, \overline{\delta})$, the equilibrium profit decreases with $\delta$. Moreover, the first-best effort cannot be achieved under opaqueness.

Opaqueness is optimal only if it is sequentially rational for the firm to retain an agent even on the punishment path (as discussed above, if this is not the case then opaqueness is dominated by transparency). Now, consider a $\delta$ at which an opaque firm is indifferent between retaining and losing an agent on the punishment path. If the associated profit under transparency is sufficiently low compared to the opaque case, as $\delta$ increases the firm might still prefer to remain opaque. But to do so, it must lower its incentive provisions in equilibrium, that is, settle for a lower profit.

FIGURE 4

THE MAXIMAL PROFITS UNDER OPAQUENESS AND TRANSPARENCY AND THE OPTIMAL DISCLOSURE POLICY: CASE (*ii*)




Otherwise, the temptation to revert back to the equilibrium path would be too large, and it will not be sequentially rational for the firm to match an offer on the punishment path.

Moreover, if the retention gains are moderate, a $\delta$ that creates enough reputation concern to support first-best effort may be too high to ensure sequential rationality of offer matching on the punishment path.

One may also be interested to know the role of matching gains in the firm's disclosure decision. The following proposition addresses this issue.

*Proposition 3*. $\underline{\delta}$ increases with both $\mu$ and $\alpha$; $\overline{\delta}$ decreases with $\mu$ but may increase or decrease with $\alpha$.

The proposition above claims that when matching gains are high (i.e., high $\mu$), transparency is more likely to be the optimal disclosure policy. The intuition is straightforward. The opportunity cost of opaqueness is the foregone matching gains that the firm can earn under transparency (because transparency ensures efficient turnover and maximizes the available matching gains). The higher are the matching gains ($\mu$), the higher is the opportunity cost of opacity. Therefore, the firm is less likely to adopt opaqueness when the expected matching gains are high.

However, the comparative statics with respect to $\alpha$ are ambiguous. The ambiguity stems from the fact that a change in $\alpha$ has opposing effects on the firm's profit function and the (*DR*) constraint in the optimal contracting problem. For a given effort level, $\alpha$ enhances the firm's profit function. But an increase in $\alpha$ also tightens the (*DR*) constraint and, hence, reduces the maximal effort level that the firm can implement under the optimal contract. This effect reduces the profit of the firm. The sign of the aggregate effect depends on the underlying parameter values. Furthermore, the underlying parameter values also determine whether the aggregate effect is stronger or weaker under transparency compared to the opaque case.

## 5. Discussion

■ Propositions 1 and 2 are useful in understanding how a firm's reputation concern influences its optimal disclosure policy and its associated payoff. How do some of the key modelling assumptions influence these findings? This section addresses this issue. It also offers justifications for some of the main assumptions and explores the robustness of the results to certain alternative specifications. Finally, I conclude this section with a discussion about the generality of the tradeoff with turnover that I highlight in this article.

□ **Commitment to disclosure policies.** The assumption that the firm can commit to its disclosure policy is important for the findings of this article. If the firm cannot commit to its disclosure policy, given any bidding strategy for the raiders the firm may have an incentive to collude with the worker and manipulate the disclosure information so as to induce the raiders to bid aggressively. Knowing this, the raiders will deviate from their bidding strategy, and always bid for the lowest-valued worker. Consequently, there would be inefficient turnover even under transparency, and the joint surplus produced by the coalition of the firm, worker, and raiders would be reduced.

The commitment assumption is perhaps a natural starting point for the analysis discussed in this article. Indeed, in may circumstances, firms do have some commitment power on how much information about their workers' quality they will reveal to the outside labor market. One salient example is filtering information through job design. Firms may be able implement a particular disclosure policy by adopting a certain job design (e.g., deciding whether to keep professionals in-house or let them work on the client's site, as discussed in the IT firm example (see Loveman and O'Connell, 1996). Because changing the job design can be costly and/or technologically infeasible at least in the short run, the irreversibility of job design may lend credibility to the firm to commit to a disclosure policy. Similarly, a firm can commit to a disclosure policy where the information is revealed through job titles, or by public announcement of the outcome of a rank-order tournament (e.g., promotion tournaments).

Note that the firm's inability to commit to pay-per-performance contracts does not preclude the firm from committing to its disclosure policy. Even if the output is nonverifiable (and, hence, the firm cannot commit to rewarding the workers' performance), the firm can still commit to a disclosure policy by implementing certain channels of information transmission such as job design, promotion tournaments, and so forth. For example, in many service sector industries such as consulting and information technology, the measure of overall performance is often subjective (e.g., extent of client satisfaction) and difficult to verify for a third party. But firms can still filter information by controlling the client-worker interaction whenever it is technologically feasible.

□ **Matching gains from turnover.** In the model, I have assumed that the worker is always a better match with the raiders. This assumption may seem unrealistic and restrictive because the match quality can vary across generations and can often be in favor of the initial employer (especially if the worker is likely to acquire firm-specific human capital). This assumption, however, can easily be relaxed without affecting any of the qualitative results. Consider the following specification: raiders appear every period with certainty, but in every period, the match quality, say $m$, is positive with probability $\alpha$ and negative with probability $(1-\alpha)$.[17] That is,

$$m = \begin{cases} \mu & \text{with probability } \alpha \\ -\mu & \text{with probability } 1-\alpha. \end{cases} \tag{7}$$

Assume that the value of $m$ is publicly observed and it is the same for both raiders.[18] All other aspects of the model are left unchanged.

Note that under this new specification, the probability that there is a successful raid in a given period is the same as in the current model because the raid is successful only when the worker is

[17] Note that this specification also eliminates the assumption that in each period, the raiders appear with an exogenous probability $\alpha$.

[18] One can also make the match quality of a raider as an independent draw from the distribution (7). However, this would make the analysis more complex without adding any further economic insight.

better matched with the raiders. Thus, under transparency, a raid occurs with probability $\alpha$ and, under opacity, a raid happens with probability $\alpha(1-p)$ . Using this fact, and by following the steps identical to the analysis in the current model, one can argue that this specification is payoff equivalent to the current specification.[19] Hence, the main results of this article remain unaltered.

Also observe that if one interprets the first period of a worker's life as a training period, then under this alternative specification the parameter $\alpha$ can be interpreted as the extent of general human capital accumulation by the worker. An environment where $\alpha$ is close to 1 can be interpreted as a setting where the worker's acquired human capital has a large general human capital component (and, therefore, the worker can easily find alternative employment in the outside labor market). In contrast, when $\alpha$ is small, the acquired human capital has a higher firm-specific component which makes the worker less productive in the outside labor market vis-à-vis with the initial employer. The current version of the model is a special case of this scenario where $\alpha = 1$.

□ **Observability of history following turnover.** The model assumes that turnover completely obscures the history of the firm. This assumption may appear unrealistic, as one would expect that at least a few senior workers would stay with the firm even after a large raid. And a junior worker may eventually learn the firm's past from such seniors. However, this assumption should not be interpreted literally, nor is it essential for the main results of the article to hold.

The key driver of the results is the premise that "soft" information (i.e., information that is not contained in hard evidence) flows gradually rather than instantaneously within an organization (Crémer, 1993; Zack, 1999) and employee turnover hinders the flow of such information across the generations of workers (Droege and Hoobler, 2003). The punishment threat may decrease with turnover, as it may take longer for the new workers to learn the firm's past behavior. Because the firm discounts its future payoff, a delayed punishment is a lesser punishment. In other words, for the purpose of my results, it is not essential to assume that the new generation *never* gets to know the history following turnover. All that is needed is the assumption that turnover may delay the learning about any past deviation. However, I have made such an assumption solely to keep the model analytically simple while maintaining the key idea that turnover obscures history.

That soft information flows gradually rather than instantaneously within an organization is well documented in both the economics of organization (Crémer, 1993; Hermalin, 2001) and organizational behavior literatures (Fisher and White, 2000; Zack, 1999). A new employee must invest in information acquisition, learn what promises were made by the firm and how it has reacted in a particular circumstance, and what constitutes a breach of promise should an unforeseen contingency arise. These ideas can be nebulous to a new worker and he can only form an informed opinion after investing sufficient time in establishing modes of communication with experienced colleagues (Crémer, 1993; Hermalin, 2001). Indeed, information dissemination within a firm critically depends on the pattern of relationship among workers (Fisher and White, 2000). Once the relationship is established, it promotes norms of reciprocity and interpersonal trust which leads to information sharing (Nahapiet and Ghoshal, 1998). The need for building such relationships as a conduit for information sharing rules out instantaneous information transmission and makes the diffusion of information a gradual process (Droege and Hoobler, 2003).

Employee turnover leads to a loss of information because turnover weakens the relational network among employees (Droege and Hoobler, 2003). The more experienced colleagues a junior worker gets to communicate with, the more quickly he learns about the past. In a firm with high turnover, a junior has fewer opportunities to meet with seniors who might be aware of the firm's past deviations. Thus, information percolates slowly compared to a firm with low turnover. This effect delays the triggering of punishment, which, in effect, reduces the punishment threat for a defecting firm.

[19] However, the raiders' bidding strategy will now be slightly different. Under transparency, the raiders bid $\theta_i + m$ and under opacity the raiders bid $\theta_L + m$.

This argument can be formally captured by considering a slight variation in the time structure of our main model. Suppose that there are $N$ workers in each generation, and each generation lives for $2T$ periods. After every $T$ periods, a new generation of $N$ workers is hired. That is, the workers from the new ("young") generation overlap with the workers from the previous ("old") generation for the first $T$ periods of their lives. A young worker works under an implicit contract for the first $T$ periods of his life. To keep the analysis simple, assume that the implicit contract promises the bonus $B$ to a young worker payable in period $T$ of his life if he performs well (i.e., $y = 1$) throughout the first $T$ periods (e.g., the reward $B$ can be conceived as a promotion to a managerial position). However, the firm may renege on its promise to a young worker in period $T$ of his life. And if it does so, $n$ ($<N$) other workers (of the same generation), or "witnesses," instantly become aware of the deviation. But the new generation of workers learns about the history gradually through communication with the old workers. I will elaborate on the communication channel shortly.

In every $T$ periods there is a raid where a $(1 - \alpha)$ proportion of the old workers leaves the firm. In the last $T$ periods of his life a worker works on a different task and he is compensated by a fixed salary (i.e., there are no moral hazard issues in the later stage of one's career).

Assume that in any given period, a young worker receives communication from a given old worker who is still with the firm with probability $q$. The uncertainty about receiving information *from a given worker in a given period* reflects that fact that in any given period a new worker need not have the opportunity to meet with every one of his senior colleagues. And, moreover, meeting with a senior colleague does not necessarily imply that the relevant information will be communicated instantaneously because, as discussed above, information transmission may require the new worker to establish an interpersonal trust and norms of reciprocity with the old worker.

I will make two simplifying assumptions to keep the analysis easily tractable: (i) if at least one young worker learns about the deviation, the information spreads among all young workers instantaneously, and (ii) the information of deviation exogenously becomes public in two generations; that is, if anyone from generation $k$ (joining the firm in period $kT$) is cheated, then all new workers of generation $k + 2$ (joining the firm in period $(k + 2)T$) and onward always learn about the deviation.

Suppose that the firm earns $v$ per period from each of the young workers if they exert effort and 0 otherwise. Also assume that a young worker exerts effort unless he observes any past deviation; else he exerts 0 effort. Now, the punishment payoff of a firm if it cheats on the $k$th generation is[20]:

$$\underline{\Pi} = Nv\frac{1 - \delta^T(1 - q)^{\alpha nNT}}{1 - \delta(1 - q)^{\alpha nNT}} + \delta^{T+1} \times 0 = Nv\frac{1 - \delta^T(1 - q)^{\alpha nNT}}{1 - \delta(1 - q)^{\alpha nNT}}.$$

Note that $\underline{\Pi}$ increases as $\alpha$ decreases. That is, with higher turnover, the information trickles slowly and, consequently, the punishment gets delayed. Thus, this model yields the same effect of turnover that the original model demonstrates: turnover obscures history and consequently impairs the firm's ability to offer a strong implicit contract by blunting its punishment threats.

Unlike our original model, however, this model admits the possibility that once the new worker spends sufficient time in the firm interacting with his seniors, he would eventually learn the firm's past with certainty (and, hence, the firm will necessarily be punished for its deviation at some point in the future); thet is, Pr(*new workers learn the history after* $\tau$ *periods*) $= 1 - (1 - q)^{\alpha nN\tau} \rightarrow 1$ as $\tau \rightarrow \infty$.

Observe that the above discussion is based on the implicit assumption that if the firm cheats on any of its workers, the firm's deviation is *publicly* observed. However, it is also important to

[20] Note that by assumption, from the $(k + 2)$th generation the firm is always punished and earns 0 in every period. Also, in any period $\tau$ between periods $(k + 1)T$ and $(k + 2)T$, the probability that the young workers are still unaware of the past deviation is $(1 - q)^{\alpha nN\tau}$.

note that in many settings the firm's deviations may not be publicly observed by all workers. In such cases it is indeed difficult for a new employee to know whether the firm has kept its promise in the past if the "cheated" employee is no longer with the firm to share his experience. The firm's deviation may not be publicly observable for at least two reasons. (i) The *performance* of a worker may not be publicly observed by his coworkers. For example, in many service sector industries, the workers often work at the client's site (Loveman and O'Connell, 1996) and their performance is reflected by the extent to which the client is satisfied with the project outcome. Thus, how a particular worker has performed in a given fiscal year is not observed by any of his coworkers who were not on that same project working at the same client location and did not have access to the client's feedback. (ii) The firm need not make the same promise to all of its employees (see, for example, Levin, 2002). The exact nature of the implicit contract may be tailored to the nature of the job a worker has been assigned to. Therefore, coworkers need not clearly observe what promises were made to a particular worker in the first place. So, it becomes hard to ascertain whether there has been a breach of promise.

For example, Gabarro and Burtis (2006) discuss a case of a law firm that attempts to formulate a performance reward system that is deemed fair by all employees. But the key challenge is to accommodate for the fact that different lawyers practicing different types of law work on very different sets of issues. And there is no general rule that can be used to define what constitutes good performance. A good performance for a trial lawyer might be judged by whether she wins the case for her client, but for someone who practices tax law, this yardstick is virtually useless. So the implicit contracts that the firm offers to some of its tax lawyers are very different from the contracts it offers to its trial lawyers. Consequently, it is difficult for a trial lawyer to correctly ascertain whether her tax lawyer colleague is treated fairly or not.

In fact, these situations are not uncommon in settings where implicit contracts are used because these are precisely the observability of performance issues that may lead the firm to resort to implicit contracts in the first place. The assumption that turnover completely obscures history can also be conceived as a modelling representation of the aforementioned environments.

□ **Trade-off with turnover in a general context.** The tradeoff with turnover that I analyze in this article can be conceived in a more general context. In fact, the tradeoff continues to hold in any setting where the firm reduces turnover (to strengthen implicit incentives) at the cost an allocational inefficiency—the loss of matching efficiency is just one such cost. For example, the firm may decide to invest in specific human capital rather than in general skills even in an environment where the latter would be more efficient. Training in general skills enhances the workers' outside options and may induce higher turnover. Firms attempting to reduce turnover may also adopt extensive screening when recruiting because employees who do not "fit" well with the organization's culture tend to leave sooner. Such an extensive recruiting process involves higher costs and narrows down the pool of prospective employees (see Baron and Kreps, 1999). In all these settings, the firm essentially faces the same tradeoff with turnover that I have discussed here: low turnover increases trust in the organization, which allows the firm to offer stronger work incentives, but reducing turnover may be a costly endeavor for the firm.

However, the particular tradeoff that I highlight here has a direct implication for the firm's disclosure policy. Because the cost of inefficient matching varies with the firm's disclosure decision, the tradeoff with turnover translates into a tradeoff with organizational transparency.

## 6. Conclusion

■ The use of implicit contracts is widespread. These contracts are not court enforced, and they are sustained only through the threat of future retaliation by the worker (if the contracts are breached). Therefore, the sustenance of implicit contracts requires that the workers must be able to observe the game's history. The coexistence of old workers with young ones facilitates the observability of history. One may argue that when a long-lived firm hires a sequence of short-lived workers, the young workers learn the history of the firm's conduct from their predecessors.

In such a setting, turnover adversely affects the observability of history, because the old worker may leave the firm before communicating the history to the young. If the history of the game is not clearly observed by the future workers, a breach of contract may go unpunished. Consequently, the threat of future retaliation that sustains implicit contracts disappears, and the firm finds it harder to credibly commit to an implicit contract. However, turnover might have its own benefits. If workers are better matched with their prospective employers, the firm can enhance its profit by ensuring efficient turnover and extracting the matching gains up front.

The turnover rate in a firm depends on how much information about its workers' productivity the firm shares with the outside labor market. In other words, the disclosure policy of the firm affects its turnover rate, and the optimal disclosure policy must balance the aforementioned cost and benefit of turnover. An opaque firm restricts turnover by creating an adverse selection problem. Low turnover facilitates sustenance of implicit contracts but reduces the available matching gains. I formalize this tradeoff, and characterize the optimal disclosure policy. There are two main findings. First, transparency is more likely at the extremes—firms with either very high or very low reputation concerns are more likely to be transparent compared to firms with moderate reputation concerns. Second, in contrast with the standard prediction in implicit contract literature, a firm's profit need not be monotonically increasing in its reputation concerns.

Although the optimal disclosure decision of a firm can be affected by several other factors (such as hiring cost), the results developed in this article are useful in understanding how disclosure affects a firm's incentive structure through its impact on worker turnover rate.

## Appendix A

### □ Proofs omitted in the text

*Proof of Lemma 1.*

*Step 1.* Let $\overline{\delta}^T$ be the value of $\delta$ at which $\delta(1-\alpha)\pi^T(e^{FB})/(1-\delta(1-\alpha)) = c'(e^{FB})$. Because the right-hand side of the $(DR^T)$ at $e = e^{FB}$ increases with $\delta$, $\forall\delta \geq \overline{\delta}^T$, $e^{FB}$ is feasible. Thus, $\Pi^T(\delta) = e^{FB} - c(e^{FB}) + \alpha\mu + 2\bar{\theta}$, $\forall\delta > \overline{\delta}^T$.

*Step 2.* Note that $(DR^T)$ is trivially satisfied at $e = 0$. Consider the value of $\delta$ at which $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha))$ is tangent to $c'(e)$ at $e = 0$, and denote it as $\underline{\delta}^T$. Due to concavity of $\pi^T(e)$, at $\delta = \underline{\delta}^T$, $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) \leq c'(e)$ $\forall e$, with equality holding at $e = 0$. Because $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha))$ is increasing in $\delta$, $\forall\delta \leq \underline{\delta}^T$, $e^T(\delta) = 0$, and the associated profit $\Pi^T(\delta) = \alpha\mu + 2\bar{\theta}$.

*Step 3.* $\forall\delta \in (\underline{\delta}^T, \overline{\delta}^T)$, consider the values of $e$ that solve $DR^T$ with equality. Because $\pi^T(e)$ is concave and $c'(e)$ is convex, there are at most two feasible values of $e$ that solve $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) = 0$, and I have already argued that $e = 0$ is one of them. Moreover, as $\delta \in (\underline{\delta}^T, \overline{\delta}^T)$, there exists a value of $e$, say $\hat{e}^T(\delta) \in (0,\ e^{FB})$, that solves $(DR^T)$ with an equality. Step 4 establishes this claim.

*Step 4.* Recall that at $\delta = \underline{\delta}^T$, $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha))$ is tangent to $c'(e)$ at $e = 0$. As $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha))$ is continuous and increasing in $\delta$, for any $\delta = \delta' > \underline{\delta}^T$, there exists an $\epsilon > 0$ depending on $\delta$, such that the $(DR^T)$ is slack at $e = \epsilon$. So $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) - c'(e) > 0$ at $e = \epsilon$. But $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) - c'(e) < 0$ at $e = e^{FB}$ because $\delta < \overline{\delta}^T$. Now, by the mean value theorem, I claim that there exists a value of $e$, say $\hat{e}^T(\delta) \in (0,\ e^{FB})$, where $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) - c'(e) = 0$.

*Step 5.* As $\forall e < e^{FB}$, $\pi^T(e)$ is increasing in $e$, and $e^T(\delta)$ is the highest value of $e$ that solves $(DR^T)$ with an equality. Hence for $\forall\delta \in (\underline{\delta}^T, \overline{\delta}^T)$, $e^T(\delta) = \hat{e}^T(\delta)$. Thus, the associated profit is $\hat{\Pi}^T(\delta) = \pi^T(\hat{e}^T(\delta))$. It remains to show that $e^T(\delta)$ is continuous and weakly increasing in $\delta$. This will also prove that $\Pi^T(\delta)$ is continuous in $\delta$, because $\pi^T(e)$ is continuous in $e$.

*Step 6.* As the right-hand side of the $(DR^T)$ is increasing in $\delta$, so is $\hat{e}^T(\delta)$. This implies that $e^T(\delta)$ is weakly increasing in $\delta$. To show that $e^T(\delta)$ is continuous, I claim that $\hat{e}^T(\delta)$ is continuous and $\hat{e}^T(\delta) \to 0$ (*or* $e^{FB}$) as $\delta \to \underline{\delta}^T$ (*or* $\overline{\delta}^T$). The continuity of $\hat{e}^T(\delta)$ follows from the fact that $\pi^T(e)$ is continuous. The limit results can be obtained by applying the implicit function theorem on the function $\delta(1-\alpha)\pi^T(e)/(1-\delta(1-\alpha)) - c'(e) = 0$ at the neighborhoods of $(e = 0, \delta = \underline{\delta}^T)$ and $(e = e^{FB}, \delta = \overline{\delta}^T)$.

*Proof of Lemma 2*. The $(DR^O)$ and $(SR)$ constraints jointly imply that any feasible $e$ must satisfy the following condition:

$$c'(e) \leq \frac{\delta(1-\alpha(1-p))}{1-\delta(1-\alpha(1-p))}(e-c(e)) \leq \theta_H - \theta_L - \mu.$$

Hence, if $\theta_H - \theta_L - \mu < c'(e^{FB})$, there does not exist any $\delta$ for which both $(DR^O)$ and $(SR)$ are satisfied at $e = e^{FB}$.

*Proof of Proposition 1*.

*Step 1*. Note that $\underline{\delta}^O < \underline{\delta}^T$ . So, if $\delta \in (\underline{\delta}^O, \underline{\delta}^T)$, $\Pi^O(\delta)$ is increasing while $\Pi^T(\delta)$ is constant at $\alpha\mu + 2\bar{\theta}$. Thus, $\Pi^O(\delta)$ can intersect $\Pi^T(\delta)$ in the interval $(0, \underline{\delta}^T)$ at most once. Denote this point as $\underline{\delta}$. If such an intersection point does not exist, then one of two cases can arise: (i) $\Pi^O(\delta)$ never intersects $\Pi^T(\delta)$. This is the case where transparency is always optimal. (ii) $\Pi^O(\delta)$ does intersect $\Pi^T(\delta)$, in which case, denote the smallest $\delta$ that solves $\Pi^O(\delta) = \Pi^T(\delta)$ as $\underline{\delta}$ (with an abuse of notation). Hence, if transparency is not optimal for all $\delta$, there exists a value of $\delta$, $\underline{\delta}$, such that transparency is strictly optimal for all $\delta < \underline{\delta}$.

*Step 2*. Next, I claim that if transparency is not optimal for all $\delta$, then there must exist a value of $\delta$, say $\bar{\delta}$, such that transparency is always optimal for all $\delta > \bar{\delta}$. Note that the highest value of $\Pi^O(\delta)$ is obtained at $\delta = \delta^*$ (where $(SR)$ starts to bind). Also, recall that $\Pi^T(\delta)$ is strictly increasing for all $\delta \in (\underline{\delta}^T, \bar{\delta}^T)$ and, by assumption, $e^{FB}$ is never obtained under opacity. So, $\Pi^O(\delta^*) < \Pi^T(\bar{\delta}^T) = e^{FB} - c(e^{FB}) + \alpha\mu + 2\bar{\theta}$. Thus, if $\Pi^O(\delta^*) > \Pi^T(\delta^*)$, then $\delta^* < \bar{\delta}^T$ and there must be a unique $\delta \in (\delta^*, \bar{\delta}^T)$ such that $\Pi^O(\delta) = \Pi^T(\delta)$ (because $\Pi^O(\delta)$ and $\Pi^T(\delta)$ are continuous and $\Pi^O(\bar{\delta}^T) < \Pi^T(\bar{\delta}^T)$). Denote this value of $\delta$ as $\bar{\delta}$. Also, if $\Pi^O(\delta^*) < \Pi^T(\delta^*)$ then there must be a value of $\delta < \delta^*$ such that $\Pi^O(\delta) = \Pi^T(\delta)$ (because we are considering the case where $\Pi^O(\delta)$ intersects $\Pi^T(\delta)$ at least once and if $\Pi^O(\delta^*) < \Pi^T(\delta^*)$, there cannot be any value of $\delta > \delta^*$ where $\Pi^O(\delta) = \Pi^T(\delta)(\Pi^O$ is decreasing and $\Pi^T$ is increasing for all $\delta > \delta^*$). Denote this the maximum value of such $\delta$ as $\underline{\delta}$. Hence, if transparency is not optimal for all $\delta$, there must also exist a value of $\delta$, $\bar{\delta}$, such that transparency is strictly optimal for all $\delta > \underline{\delta}$. Therefore, if transparency is not optimal for all $\delta$, opacity can be optimal only if $\delta \in (\underline{\delta}, \bar{\delta})$.

*Proof of Proposition 2*. Lemma 3 suggests that there exists a $\delta^*$ such that $\Pi^{O\prime}(\delta) < 0\ \forall \delta > \delta^*$. Moreover, the proof of Proposition 1 suggests that if there exists an interval $(\underline{\delta}, \bar{\delta})$ where opaqueness is optimal, $\delta^* \in (\underline{\delta}, \bar{\delta})$. The proof of the proposition directly follows from these two facts. Furthermore, when it is sequentially rational for an opaque firm to match the raiders' offer even on the punishment path (which must be the case if opaqueness is the optimal disclosure policy), Lemma 2 shows that (given Assumption 4) the first-best effort is not feasible.

*Proof of Proposition 3*.

*Step 1*. Denote $\Delta\Pi(\delta; \alpha, \mu) = \Pi^T(\delta; \alpha, \mu) - \Pi^T(\delta; \alpha, \mu)$. Now, by definition of $\underline{\delta}$ and $\bar{\delta}$, $\Delta\Pi(\underline{\delta}; \alpha, \mu) \equiv \Delta\Pi(\bar{\delta}; \alpha, \mu) \equiv 0$. Hence, by chain rule, for $x \in \{\alpha, \mu\}$ and $\delta \in \{\underline{\delta}, \bar{\delta}\}$,

$$\frac{\partial\delta}{\partial x} = -\frac{\partial\Delta\Pi(\delta; \alpha, \mu)/\partial x}{\partial\Delta\Pi(\delta; \alpha, \mu)/\partial\delta}.$$

Now, from the proof of Proposition 1 it follows that $\partial\Delta\Pi(\underline{\delta}; \alpha, \mu)/\partial\delta < 0$ and $\partial\Delta\Pi(\bar{\delta}; \alpha, \mu)/\partial\delta > 0$. So, at $\delta = \underline{\delta}$, $sign(\partial\delta/\partial x) = sign(\partial\Delta\Pi(\underline{\delta}; \alpha, \mu)/\partial x)$ and at $\delta = \bar{\delta}$, $sign(\partial\delta/\partial x) = -sign(\partial\Delta\Pi(\bar{\delta}; \alpha, \mu)/\partial x)$.

*Step 2*. First, consider the case where $\delta = \underline{\delta}$ .

*Step 2a*. Consider the case of $x = \mu$. By envelope theorem,

$$\frac{\partial}{\partial\mu}\Pi^T(\underline{\delta}) = \alpha, \text{ and } \frac{\partial}{\partial\mu}\Pi^O(\underline{\delta}) = \alpha(1-p).$$

Hence, $\partial\Delta\Pi(\underline{\delta}; \alpha, \mu)/\partial\mu > 0$ and so, $\partial\underline{\delta}/\partial\mu > 0$.

*Step 2b*. Consider the case of $x = \alpha$. Again, by envelope theorem,

$$\frac{\partial}{\partial\alpha}\Pi^T(\underline{\delta}) = \mu \text{ and } \frac{\partial}{\partial\alpha}\Pi^O(\underline{\delta}) = \mu(1-p) + \lambda_1^O(\underline{\delta})\frac{\partial}{\partial\alpha}g_1^O(e^O(\underline{\delta}); \alpha, \mu),$$

where $g_1^O(e; \alpha, \mu) := \delta(1-\alpha(1-p))(e-c(e))/(1-\delta(1-\alpha(1-p))) - c'(e)$ and $\lambda_1^O$ is the Lagrange multipliers for the $(DR^O)$ constraints in the optimal contracting program $\mathcal{P}^O$ (I also use the fact that the $(SR)$ constraint in $\mathcal{P}^O$ cannot be binding at $\delta = \underline{\delta}$, and hence the value of its associated Lagrange multiplier is 0). Now, because $(DR^O)$ is binding at $e = e^O(\underline{\delta})$, it must be the case that $\lambda_1^O(\underline{\delta}) > 0$. Furthermore, $\partial g_1^O(e^O(\underline{\delta}); \alpha, \mu)/\partial\alpha < 0$. Hence, $\partial\Pi^T(\underline{\delta})/\partial\alpha > \partial\Pi^O(\underline{\delta})/\partial\alpha$, or $\partial\Delta\Pi(\underline{\delta}; \alpha, \mu)/\partial\alpha > 0$. So, $\partial\underline{\delta}/\partial\alpha > 0$.

*Step 3*. Next, consider the case where $\delta = \bar{\delta}$. Without loss of generality, I assume that $(SR)$ is binding (and hence $(DR^O)$ is slack) at $\delta = \underline{\delta}$ .

*Step 3a*. Consider the case of $x = \mu$. By envelope theorem,

$$\frac{\partial}{\partial\mu}\Pi^T(\bar{\delta}) = \alpha, \text{ and } \frac{\partial}{\partial\mu}\Pi^O(\bar{\delta}) = \alpha(1-p) + \lambda_2^O\frac{\partial}{\partial\mu}g_2^O(e^O(\bar{\delta}); \alpha, \mu),$$

where $g_2^O(e; \alpha, \mu) := (\theta_H - \theta_L - \mu) - \delta(1-\alpha(1-p))(e-c(e))/(1-\delta(1-\alpha(1-p)))$. Now, $\frac{\partial}{\partial\mu}g_2^O(e^O(\bar{\delta}); \alpha, \mu) < 0$ and $\lambda_2^O > 0$ because $(SR)$ is binding. Hence, $\partial\Pi^T(\bar{\delta})/\partial\mu > \partial\Pi^O(\bar{\delta})/\partial\mu$, or $\partial\Delta\Pi(\bar{\delta}; \alpha, \mu)/\partial\mu > 0$. So, $\partial\bar{\delta}/\partial\mu < 0$.

*Step 3b.* Finally, consider the case of $x = \alpha$. Again, by envelope theorem,

$$\frac{\partial}{\partial\alpha}\Pi^T(\overline{\delta}) = \mu + \lambda^T \frac{\partial}{\partial\alpha} g^T(e^T(\overline{\delta}); \alpha, \mu), \text{ and } \frac{\partial}{\partial\alpha}\Pi^O(\overline{\delta}) = \mu(1-p) + \lambda_2^O \frac{\partial}{\partial\alpha} g_2^O(e^O(\overline{\delta}); \alpha, \mu).$$

Now, $\lambda^T \frac{\partial}{\partial\alpha} g^T(e^T(\overline{\delta}); \alpha, \mu)$ and $\lambda_2^O \frac{\partial}{\partial\alpha} g_2^O(e^O(\overline{\delta}); \alpha, \mu)$ cannot be ranked. Hence, $\frac{\partial}{\partial\alpha}\Delta\Pi(\overline{\delta})$ cannot be signed, and therefore, the sign of $\partial\overline{\delta}/\partial\alpha$ is ambiguous.

## Appendix B

□ **Supplementary analysis in the case of an opaque firm.** This appendix elaborates on the analysis for the optimal contract in an opaque firm when the firm does not retain the agent on the punishment path. First, note that when an opaque firm does not retain any agent on the punishment path, it faces the same turnover rate (i.e., $\alpha$) that a transparent firm does. Also note that because the raiders know that the game is on the punishment path and the firm does not retain any agents, they will bid the average productivity of the agents, that is, $\beta_j = \bar{\theta} + \mu,\ j = 1, 2$. Using these two facts, one can derive the continuation payoff of the firm on the punishment path as follows (the derivation is similar to the derivation of equation (4)):

$$\underline{\Pi}_n^O = \frac{1}{1-\delta(1-\alpha)}\left[\alpha\overline{\Pi}^O + (1-\alpha)\left(\alpha\mu + 2\bar{\theta}\right)\right].$$

Also note that in this case, when the firm defects on a $\theta_H$-type worker in generation $t$, the firm's payoff in period 2 of generation $t$ is $(1-\alpha)(\theta_H - w_2)$ but its payoff on the equilibrium path is $\alpha(\theta_H - \theta_L - \mu) + (1-\alpha)(\theta_H - w_2)$. Thus, the $(DR)$ constraint in this case is

$$\alpha(\theta_H - \theta_L - \mu) + \delta\overline{\Pi}^O \geq B + \delta\underline{\Pi}_n^O. \qquad (DR_n{}^O)$$

The $(DR)$ constraint for the $\theta_L$-type worker is $\delta\overline{\Pi}^O \geq B + \delta\underline{\Pi}_n^O$. It is less binding than $(DR_n^O)$ because there is always turnover for such a worker even on the equilibrium path. Now, the optimal contract of an opaque firm that does not retain the $\theta_H$-type agent on the punishment path must satisfy the following sequential rationality constraint:

$$\delta\overline{\Pi}^O \geq (\theta_H - \bar{\theta} - \mu) + \delta\underline{\Pi}_n^O. \qquad (SR_n)$$

Similar to the $(SR)$ constraint, the $(SR_n)$ constraint requires that the firm's payoff from the reversion to equilibrium play from the immediate next generation ($\delta\overline{\Pi}^O$) must be (weakly) greater than its payoff from retaining the $\theta_H$-type agent ($(\theta_H - \bar{\theta} - \mu) + \delta\underline{\Pi}_n^O$).

How does the optimal contract of an opaque firm change if it does not match the raiders' offers on the punishment path? Similar to the program $\mathcal{P}^O$, the optimal contracting problem can be written as

$$\mathcal{P}_n^O : \begin{cases} \max_e e - c(e) + \alpha(1-p)\mu + 2\bar{\theta} \\ s.t. \quad \alpha(\theta_H - \theta_L - \mu) + \delta(1-\alpha)[e - c(e) - \alpha p\mu]/(1 - \delta(1-\alpha)) \geq c'(e), \ (DR_n^O) \\ \delta(1-\alpha)[e - c(e) - \alpha p\mu]/(1-\delta(1-\alpha)) \geq \theta_H - \bar{\theta} - \mu. \qquad (SR_n) \end{cases}$$

Let $\Pi_n^O(\delta)$ be the value associated with $\mathcal{P}_n^O$ and denote $\rho = \delta(1-\alpha)/(1-\delta(1-\alpha))$. An important observation emerges while comparing $\mathcal{P}_n^O$ with $\mathcal{P}^T$: if $\rho \geq (\theta_H - \theta_L - \mu)/p\mu$, then any $(\delta, e)$ pair that satisfies $(DR_n^O)$ must also satisfy $(DR^T)$. Moreover, for a given $e$, the profit in $\mathcal{P}^T$ is greater than that in $\mathcal{P}_n^O$. But the minimum value of $\rho$ for which $(SR_n)$ can be satisfied is $\rho^* = (\theta_H - \bar{\theta} - \mu)/(e^{FB} - c(e^{FB}) - \alpha p\mu) = (\theta_H - \bar{\theta} - \mu)/(1/2\gamma - \alpha p\mu)$. So, if $(\theta_H - \theta_L - \mu)/p\mu \leq \rho^*$, then any feasible solution to $\mathcal{P}_n^O$ is also feasible in $\mathcal{P}^T$ and yields higher profit under transparency. A sufficient condition for $(\theta_H - \theta_L - \mu)/p\mu \leq \rho^*$ to hold is $\gamma \geq 1/2(1+\alpha)p\mu$, and we will maintain this assumption. Thus, one can claim the following (I omit the proof as it has already been discussed above):

*Lemma 4.* For all $\delta \in [0, 1)$, $\Pi^T(\delta) > \Pi_n^O(\delta)$.

The above lemma has a crucial implication. An opaque firm can do better by becoming transparent if it is never sequentially rational to match the raiders' bid on the punishment path. This observation justifies the claim that if opaqueness emerges as the optimal disclosure policy in equilibrium, it must be the case that the firm finds it sequentially rational to retain a $\theta_H$-type agent even on the punishment path.

The intuition behind this result is simple and can be traced from the benefit of opaqueness over transparency. An opaque firm can credibly promise a higher bonus payment than its transparent counterpart. Such commitment power stems from the adverse selection problem that is created by opaqueness. The adverse selection problem results in lower turnover. Lower turnover implies more severe punishment (by increasing the expected duration of the punishment) if the firm reneges on its bonus promises.

However, if an opaque firm does not match the raiders' bid on the punishment path, it induces the same turnover rate as in a transparent firm. Thus, the firm fails to realize the benefits of opaqueness on incentive provision, but it does incur the loss of matching surplus. This is due to the fact that on the equilibrium path, both types of agents leave the firm at the low-type worker's wage (note that on the equilibrium path the raiders bid only for the low-type worker, $\theta_L + \mu$, due to the adverse selection problem). Consequently, the firm extracts a smaller amount of surplus compared to the transparent case, where the raiders bid the full value of each type of agent (therefore the expected bid on the equilibrium path is $\bar{\theta} + \mu > \theta_L + \mu$). But, there is an additional effect: when an opaque firm does not retain any worker on the punishment path, it foregoes the retention profits on the high-type worker. This effect further relaxes its (*DR*) constraint compared to the case of the transparent firm (given by the $\alpha(\theta_H - \theta_L - \mu)$ term in ($DR_n^O$) above). But this effect is of second order to the negative effect of the loss of matching surplus (given by the $-\alpha p \mu$ term in ($DR_n^O$)) when $\gamma$ is not too small. Because this effect is not central to the tradeoff we are interested in, we make this assumpton (i.e., $\gamma$ is larger than a threshold) to keep the analysis simple. Hence, under this assumption, we obtain that the payoff from transparency dominates the payoff from opaqueness when raiders' bids are never matched on the punishment path.

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