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ABSTRACT

Layoffs as Part of an Optimal Incentive Mix: Theory and Evidence*

Firms offer highly complex contracts to their employees. These contracts contain a mix of incentives, such as fixed wages, bonus payments, promotion options, and layoff threats. In general, economists understand how incentives motivate employees but not why a particular mix should be used. In this paper we present a model in which the observed incentive mix is an optimal contract. In particular, we show that it can be optimal for firms to combine cost-efficient incentives such as promotions and bonuses with layoffs. The intuition is that layoffs play a dual role. First, they create incentives for the employees. Second, they contribute to sorting and selection. In the empirical part of the paper we test the model's basic assumption about employee sorting and selection together with its broader predictions about employee careers. Using personnel records from a large international pharmaceutical company, we find that the model's predictions are consistent with the data.

JEL Classification: J30, J41, M50

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1 Motivation

Firms use a variety of economic incentives to motivate their employees. The observed incentive mix often contains fixed wages, bonus payments, promotion options, and layoff threats. In general, economists understand why firms choose each element of the incentive mix, but not why firms prefer a specific mix. Understanding the reasons why a mix of incentives arises has strong policy implications, besides contributing to our knowledge of personnel economics. The reason is that in many labor markets layoffs, which are an important part of the incentive mix, are constrained. Thus, understanding the economic role of the incentive mix, and in particular the role of layoffs, provides an important insight into the effects of labor market regulations.

In this paper, we first present a theoretical model of how incentives are used in firms. Our main finding is that firms with production technology sensitive to the quality of the workforce may find it optimal to combine cost-efficient incentives such as bonus payments and promotions with layoffs. Consequently, quality-concerned firms operating in heavily regulated labor markets where layoffs are highly restricted or very costly will face a comparative disadvantage when competing internationally.

Second, we use the personnel records from an international pharmaceutical company to test the theoretical model and its predictions. The aim of this exercise is to improve our understanding of the empirical consequences of layoffs because it is an area that is only vaguely understood in the literature, see Baker, Jensen and Murphy [1988]. What makes the investigated firm particularly interesting in this context is that it offers an employment contract to its employees, which contains fixed wages, bonus payments, promotion options, and layoff threats. Thus, the data allow us to observe the full incentive mix at work and by that investigate the effects of layoffs empirically.

The evidence that firms offer a mix of incentives to their employees is accumulating, see Medoff and Abraham [1980, 1981]; Baker, Gibbs, and Holmström [1994a,b]; Gibbs [1995]; Farrall and Shearer [1999]; and Lazear [1992, 2000]. Nevertheless, conventional economic theory has addressed the various incentive mechanisms in separate frameworks. First, the performance-pay literature, which originates from Mirrlees [1974, 1976] and Holmström [1979, 1982], explains why pay should be linked to output. According to this theory, wages should include variable elements such as bonuses or piece rate to reward employee effort. Second, the efficiency-wage literature started off by Shapiro and Stiglitz [1984] emphasizes the incentive-effect of layoffs, or the threat of layoffs.

Tournament theory, initiated by Lazear and Rosen [1981], integrates the use of incentives in a competitive framework. If the number of workers rewarded, laid off, or promoted is preset, workers have an incentive to exert effort. In principle, tournament theory explains why firms would use any element of the incentive mix. Tournament theory, however, cannot explain why the firm prefers a specific mix of incentives.

MacLeod and Malcolmson [1998] analyze the relative merits of different incentive tools. They contrast efficiency wage and performance pay incentives, that is, layoffs and bonus payments, as incentive tools. Under the efficiency wage system, firms pay rents ex-ante and provide incentives by laying off shirking workers. Under the performance-pay regime, firms pay bonuses ex-post, conditional on effort. The model shows that efficiency-wage incentives are generally more expensive. Yet, if the firm cannot commit to pay bonuses, efficiency wages might be the only way to motivate employees because they give compensation up-front. The results, however, do not

answer the question why the observed incentive mix arises. In the MacLeod and Malcolmson [1998] setup either efficiency wage or performance pay prevails.

To understand why firms use a mix of incentives, we propose a theoretical model where the firm has the option to offer the full incentive mix of fixed wages, bonus payments, promotion options, and layoff threats to its employees. Our first result is that it is optimal for firms facing a homogenous workforce to motivate employees through bonus payments and promotions; but they should not lay off employees. Thus, the empirically observed incentive mix does not arise. The reason is that in contrast to promotions and bonus payments, layoffs are wasteful. Layoffs are costly for both the firm (recruiting and training of new employees) and the employee (job search), and in equilibrium the firm shoulders all these costs. Hence, the firm prefers to offer promotions and bonuses over threatening employees with layoffs.

In a second step, we extend the basic model to accommodate employee heterogeneity. The profit-maximizing firm is now concerned about job assignment because the overall productivity of the firm depends upon the quality of its employees and their job allocation. These concerns create a trade-off for the firm. Increasing layoffs induces additional costs on the firm but simultaneously increases employee quality. This trade-off explains why the firm prefers to use the delicate mix of incentives observed in our data.

The theoretical model proposes a hierarchy of incentives. When the workforce is homogenous, incentives created by promotions will be exploited first. If additional incentives are required, the firm will turn to bonus payments. Layoffs will not be used for incentive purposes. In contrast, when the firm faces a heterogenous workforce, the hierarchy of incentives changes. Now incentives through promotions and layoffs are used first. The reason for this change is the dual role of promotions and layoffs, i.e., besides creating incentives, they contribute to employee sorting and selection.

The contract offered to employees, and in particular the use of layoffs, has profound implications for within-firm dynamics. We explore these implications in order to characterize the firm's selection scheme and to make predictions about the employees' careers. Of primary interest is the result that the quality of the workforce within a given organizational rank may increase with tenure, i.e., positive selection on tenure may arise. In the data analysis this result is shown to have empirical relevance. Thus, it is established that selection on tenure is not necessarily negative as argued in earlier research by Medoff and Abraham [1980, 1981], Lazear [1992, 2000], and Gibbs [1995]. This finding is important because, as Guasch and Weiss [1980] suggest, it shows that selection constitutes an interesting alternative to on-the-job human-capital acquisition in explaining the effects of tenure on earnings. In fact, selection alone can justify a positively sloped earning profile with tenure.

Information about the firm's selection regime provides additional predictions about the employees' careers, which can be tested empirically. In accordance with the model, we find empirical support for performance based sorting and confirm predictions about the employee's likelihood of receiving a bonus payment, being promoted, or laid off. By contrasting the broad set of predictions to data, we comply with the Gibbons and Waldman [1999a,b] critique, which states that many models may be able to explain a single empirical finding (such as the observed incentive mix) but often fail to explain a broader pattern of empirical evidence.

In the next section, we outline the basic model. In Section 3, the model is extended to accommodate employee heterogeneity, and the firm's selection scheme is discussed in detail. In

Section 4, the models empirical predictions are stated explicitly. The data are presented in section 5, and the close relation between the empirical contract and the theoretical model is emphasized. In section 6, we test the model's predictions empirically. A detailed discussion of the model's limitations and suggestions for future research are presented in section 7. Finally, the results found in this paper are summarized and a conclusion is provided in section 8.

2 Basic model

In this section we present a theoretical model in which the firm has the option to offer a contract containing a fixed wage, bonus payments, promotion options, and layoff threats to a group of homogenous employees. The contract is constructed such that it secures both participation and effort exertion from the employees. The main purpose is to study if this initial setup is capable of producing an optimal contract which matches the observed incentive mix. In other words, we want to investigate if it is optimal for the firm to use the full set of incentives observed empirically in the contract it offers to its employees.

The model entails the contracting relationship between a risk-neutral firm and a continuum of risk-neutral employees in a two-period game. The firm and the employees form a principal-agent relationship. The firm maximizes expected profit while the employees maximize their expected utility.

In the first period, the firm offers an employment contract in terms of fixed wages, bonus payments, promotions, and layoffs. The timing of events is as follows:

1. The firm offers a contract to prospective employees. If they accept it, they are hired.
2. Employees decide about the effort level, which is not observed by the firm.
3. Output is realized and observed by all.
4. Bonuses are paid; employees are promoted or laid off.

The second period captures the "long-run" consequences of the first period job assignment decisions, i.e., the consequences of promoting and laying off a proportion of the first period employees. This implies that in the second period the firm has to replace employees leaving the non-management level due to layoffs and promotions, and it may have to fill management vacancies by hiring externally. To maintain focus, we assume that employees produce output in the second period without an explicit incentive problem.

The employees produce binary output in the first period, which is normalized to 0 (low) or C (high), where $C > 0$. The probability for output C is θ, and naturally $\theta \in (0, 1)$. The employee, once having accepted the job, can influence the probability of high output by exerting effort. The utility cost of effort exertion is e, and effort increases the probability of success by $\delta > 0$. The table below summarizes the probabilities:

	without effort	with effort
low output (0)	$1 - \theta$	$1 - \theta - \delta$
high output (C)	θ	$\theta + \delta$

The effort is worth undertaking, i.e., the private costs of effort are strictly less than the production gains, formally: $e < \delta C$. We further assume that $\theta + \delta < 1$.

The utility of the employee's alternative job options is denoted by $\bar{U} > 0$. Furthermore, the additional utility of a promotion is $U_P > 0$, and the utility cost from being laid off is $U_F > 0$, while there is no utility change if the employee stays with the firm in the same rank. The utility gains of promotion stem from managerial rents and is discussed in detail in the appendix. The utility loss from firing reflects that if an employee is laid off, he or she must search for a new job, which is costly because there are frictions in the labor market.

The firm sets the first period employment contract through the following four parameters: $\{w,b,\pi_P,\pi_F\}$. First, a fixed wage (w) is offered to all individuals who accept the job irrespective of performance. The remaining three parameters are conditional on performance. It is assumed that bonus payments (b) are paid to well-performing agents, employees with high observable output (high performance) are considered for promotion, and employees with low observed output (low performance) are at risk of being laid off. The conditional promotion probability and the conditional layoff probability are denoted by π_P and π_F, respectively. The parameters are (realistically) constrained as follows: $w,b \geq 0$; $\pi_F,\pi_P \in [0,1]$.[1]

$\{0, C\}$	output realizations
M	managerial output
F	output in the second period
θ	probability that output is high
δ	probability increase with effort
e	effort cost
$\bar{U}$	utility of alternative job option
U_P	utility of a promotion
U_F	utility cost from being fired
H	size-ratio of managerial and employee rank
w	fixed wage
b	bonus paid conditional on high output
π_P	probability of promotion conditional on high output
π_F	probability of layoff conditional on low output

Table 1: Model parameters

Turnover is costly because it imposes training and recruiting costs on the firm. These costs are summarized in the turnover-cost parameter $K > 0$. The equilibrium volume of firm-initiated separations when high effort is elicited is $(1 - \theta - \delta)\pi_F$.

Even though employees desire promotion, the number of employees who can be promoted is constrained by the number of vacant positions in management. That is, the volume of promotions $(\theta + \delta)\pi_P$ is constrained by the volume of exogenous job openings at the managerial level, which is normalized to $1/H$. Parameter H can be interpreted as the hierarchical size difference between non-management and management rank. The above argumentation is summarized in the promotion-constraint (P):

$$(\theta + \delta)\pi_P \leq \frac{1}{H} \tag{1}$$

[1] Conditioning bonus, promotion and layoffs on output, as above, can be done without the loss of generality, which can be seen from the discussion in the appendix. Furthermore, the continuum of employees makes the contract easily enforcible, even with non-integer probabilities.

It is assumed that $(\theta + \delta) < H$, which implies that not all well-performing employees can be promoted.

In the second period, the firm has two hierarchical ranks: non-management and management. The two-layer hierarchy provides the simplest setting in which the incentive mix can be analyzed without analyzing complicated multi-layer hierarchies. Employees uniformly produce output F, and employee compensation is normalized to zero. Managers consist of promoted non-management employees and individuals hired from the external labor market directly into management. Managerial incentives and participation are not modeled explicitly, and their contribution to the firm's profit is the fixed-value M. We assume that $F < M$, i.e., managerial output is more important than employee output. This follows from the fact that managers affect the output of multiple non-management employees. Manager pay is also normalized to zero in order to focus on incentives at the non-management level.

In order to keep the analysis tractable, it is assumed that the firm has all the bargaining power. Furthermore, two tie-breaking rules are imposed. First, indifferent players act such that the other player is better off. Second, employees are assumed to prefer less risky payments with the same mean as a form of moderate risk aversion. The model's parameters are presented in Table 1.

Finally, the observed incentive mix is defined:

Definition 1 *The observed incentive mix is the equilibrium in which the firm strictly prefers to set all the parameters* $\{w,b,\pi_P,\pi_F\}$ *to non-zero values.*

2.1 Contracting problem

The contracting problem is summarized in the following equations:

$$\max_{w,b,\pi_F,\pi_P} (\theta+\delta)C + M/H + F - w - (\theta+\delta)b - (1-\theta-\delta)\pi_F K - \frac{K}{H} \tag{2}$$

subject to

$$\begin{array}{lrcl}
(IC) & w - e + (\theta+\delta)[b + \pi_P U_P] - (1-\theta-\delta)\pi_F U_F & \geq & w + \theta[b + \pi_P U_P] - (1-\theta)\pi_F U_F \\
(IR) & w - e + (\theta+\delta)[b + \pi_P U_P] - (1-\theta-\delta)\pi_F U_F & \geq & \bar{U} \\
(P) & (\theta+\delta)\pi_P & \leq & \dfrac{1}{H} \\
\text{non-negativity} & w, b & \geq & 0 \\
\text{probability} & \pi_F, \pi_P & \in & [0,1]
\end{array}$$

Intuitively, the program above states that the firm maximizes profit. Employees contribute to firm profit by providing the high output C with probability $(\theta + \delta)$ in the first period. In the second period managers and employees both contribute to firm profitability. Each manager contributes to profit by M, and their number is $1/H$. Employees produce output F.

In exchange for time and effort, employees are compensated. The firm pays fixed wages (w) with certainty and bonuses (b) with probability $(\theta + \delta)$. In addition, the firm has to incur costs of turnover (K) from two sources. First, it lays off low performing employees with probability π_F. Second, it has to hire the volume $1/H$ employees either to fill management positions or to

replace promoted employees. Finally, managerial and employee pay is normalized to zero in the second period; thus, it is not displayed.

The IC-constraint implies that the employee accepting the contract is better off by exerting the first-best high effort in the first period. The left-hand side shows the worker's utility given effort. The employee receives the fixed wage (w) and incurs the cost of effort (e). Furthermore, the probability ($\theta + \delta$) of high output leads to bonus payments (b) and chances for promotion (π_P), which provides utility (U_P). Also, the employee has a lower probability $(1 - \theta - \delta)\pi_F$ of being laid off and hereby incurring the disutility (U_F). The right-hand side shows the worker's compensation without effort-exertion. Here the chances for bonuses and promotions are lower (θ) and that of layoff $(1 - \theta)\pi_F$ higher. Thus, bonuses, promotions, and layoffs are in principle used to induce effort.

The IR-constraint states that employees are better off accepting the contract. The left-hand side of the equation is the same as in the IC-constraint, i.e., the utility of exerting effort. This utility must exceed the utility of the employee's outside option ($\bar{U}$).

The other constraints follow directly from the assumptions. Wages and bonuses must be non-negative as the non-negativity constraints imply. Finally, conditional firing and promotion probabilities must be on the unit interval.

2.2 Solving the basic model

Notice first that in equilibrium the promotion constraint (P) is always binding while the promotion probability (π_P) is still less than unity. If P is slack, the firm can increase promotions and in exchange decrease bonuses, fixed wages, and the costly layoffs, which naturally leads to higher profits. Alternatively, the firm can increase employee welfare. Hence, even in the case where wages, bonuses, and layoffs all take zero values, the firm can increase the welfare of its employees without additional costs. Thus, in equilibrium the P-constraint is binding. In other words, there are ports of entry, as suggested in Doeringer and Piore [1971].

By definition, the observed incentive mix arises only if all four parameters are set to non-zero values. It is thus enough to focus our attention on binding IR- and IC-constraints. To see that, consider the following. First, either the individual rationality (IR) constraint binds or the wage is set to zero in the profit-maximizing equilibrium. If it does not bind, the wage must be zero, or else the firm would reduce the fixed wage and thereby increase its profit.

Similarly, the incentive compatibility constraint (IC) binds or the bonus is set to zero in equilibrium. If the IC-constraint does not bind, the bonus must be zero, or else the firm would decrease bonus payments. If the IR-constraint binds, the firm can lower bonus payments (and increase fixed wages) to make the employees better off. If the IR-constraint does not bind, the firm can lower bonus payments without wage compensation and increase profits.

In sum, the observed incentive mix can only arise when all the IR-, IC- and P-constraints bind. Consequently, whenever the observed incentive mix is possible, the original four-parameter incentive problem is reduced to a single-parameter optimization. Expressing the profit as a function of π_F, the first-order condition reveals that the objective function is maximized when the layoff probability is minimized and set to zero. Thus, the observed incentive mix cannot arise in the basic model.

The intuition is that layoffs are more costly than promotions and bonuses to motivate workers.

Layoffs creates two social costs: cost of hiring and utility loss of firing. In equilibrium these two costs are born by the firm. Consequently, layoffs are necessarily set to zero. Lemma (1) summarizes the result. The proof of the lemma is provided in the appendix as are the proof of other statements.

Lemma 1 *In the basic model incentives are given through bonuses and promotions but not through layoffs. Thus, the observed incentive-mix does not arise.*

The results of the basic model can be interpreted as evidence for a hierarchy of incentives. The firm prefers to use promotions because they exploit costless residual rents. If additional incentives are needed (to satisfy the IC-constraint), the firm turns to using bonuses. Finally, to ensure worker participation (and to satisfy the IR-constraint), the firm uses fixed wages, but only if bonuses and promotions are insufficient. Layoffs, however, are never used because of their cost-disadvantage.

Finally a few words about rents in the model. By assumption there is no ex-ante rent (because the individual rationality constraint (IR) is binding). However, the fact that layoffs cause disutilities (U_F) shows that interim there is rent. The interpretation is that even though the worker is initially indifferent between the firm's offer and other offers, going back to the labor market to search is costly. Thus, interim there is rent from retaining the job, and the firm can exploit this feature to motivate the worker. However, Lemma (1) states that motivating through layoffs is more costly than motivating through bonus payments.

3 Job-assignment model

In this section, the basic model is extended to accommodate employee heterogeneity. The profit-maximizing firm is now interested in sorting and selection of employees because the quality of the workforce and the allocation of employees to jobs (non-management vs. management jobs) are important for the firm's overall productivity. This implies that the firm has an additional motivation (besides incentive purposes) to promote and lay off employees because the two devices can be used to adjust the quality of the workforce at both hierarchical levels.[2]

The job-assignment model is used for two purposes. First, it is shown that sorting and selection considerations lead to the observed incentive mix. Second, the model can be utilized to characterize the firm's selection scheme, which leads to empirical predictions about employees careers. Hence, the model provides a set of broader predictions in addition to the observed incentive mix, which can be used to establish the empirical relevance of the theoretical model.

3.1 The observed incentive mix

Potential employees are heterogeneous. There are good employees (G) with high ability and bad ones (B) with low ability. Good employees are more likely to produce a high output compared to bad employees, i.e., $\theta_G > \theta_B$. However, neither the firm nor the employee is able to observe

[2] We continue to assume that sorting is based on performance in the job assigment model. This assumption is without the loss of generailty, as discussed in the appendix.

the ability of the employee. Consequently, employees (both good and bad ability ones) face a single outside option providing utility $\bar{U}$.[3]

The firm's external labor market consists of a proportion μ of high ability individuals. Since the firm can use promotions and layoffs to sort and select employees in the first period, the second-period employee composition can differ from the composition in the external labor market. For this reason, the proportion of high ability types in the second period in non-management is denoted by μ_F, and the proportion of high ability types in management is μ_M.

Employee quality affects production in the second period because both managerial (M) and employee (F) output depend on workforce quality, i.e., $M(\mu_M)$ and $F(\mu_F)$. The output functions are assumed to be concave. Hence, the first derivatives are positive, $M', F' > 0$, and the second derivatives negative, $F'', M'' < 0$, meaning that the marginal returns to quality are decreasing. Furthermore, managerial quality is assumed to be weakly more important than employee quality, formally $M(x) \geq F(x)$ and $M'(x) \geq F'(x) : \forall x \in [0,1]$.

First, the contracting problem is outlined. As prospective employees do not know their ability, the firm is unable to write a contract to elicit self-selection ex-ante. Thus, a pooling equilibrium necessarily arises, which can be summarized as follows:

$$\max_{w,b,\pi_F,\pi_P} \frac{M(\mu_M)}{H} + [\theta_B + \mu(\theta_G - \theta_B) + \delta](C - b) + F(\mu_F) - w \qquad (3)$$
$$-[1 - \theta_B - \mu(\theta_G - \theta_B) - \delta]\pi_F K - \frac{K}{H}$$

subject to[4]

$$\begin{array}{lrcl}
(IC) & b + \pi_P U_P + \pi_F U_F & \geq & \frac{e}{\delta} \\
(IR) \quad w - e + (\theta_B + \mu(\theta_G - \theta_B) + \delta)[b + \pi_P U_P] - (1 - \theta_B - \mu(\theta_G - \theta_B) - \delta)\pi_F U_F & \geq & \bar{U} \\
(P) & (\theta_B + \mu(\theta_G - \theta_B) + \delta)\pi_P & \leq & \frac{1}{H} \\
\text{non-negativity} & 0 & \leq & w, b \\
\text{probability} & \pi_F, \pi_P & \in & [0,1]
\end{array}$$

Second, managerial and employee second-period equilibrium composition is determined in Lemma (2).

Lemma 2 *In the second period, the equilibrium proportion of good workers (μ_F) in non-management depends on the layoff and promotion probabilities:*

$$\mu_F = \mu + \mu(1 - \mu)(\theta_G - \theta_B)(\pi_F - \pi_P) \qquad (4)$$

and the proportion of good quality workers in management (μ_M) is determined as:

$$\mu_M = \mu(\theta_G + \delta)\pi_P H + \mu\left(1 - \pi_P H\ (\theta_B + \mu(\theta_G - \theta_B) + \delta)\right). \qquad (5)$$

Furthermore, μ_F increases in the layoff rate and decreases in the promotion rate.

[3] Mutually unknown ability can be thought of as modeling fresh college graduates entering a firm. The graduates might not have significant information advantage because they do not know the actual work environment.

[4] The IC-constraint displayed below saves on notation and is a straightforward simplification of both employee types' IC constraints.

The first term in equation (4) states that employee quality is affected by the quality of the workforce in the external labor market (μ). The second term summarizes the effects of on-the-job selection. In particular, it shows that employee heterogeneity affects the efficiency of the selection regime. Heterogeneity can be measured as the difference between the abilities of good and bad employees ($\theta_G - \theta_B$) and also by the variance of the distribution of the two types ($\mu(1-\mu)$). Layoffs (π_F) affect employee quality positively because layoffs are more likely to weed out bad employees. Promotion (π_P), however, decreases quality because better employees are more likely to be promoted.

Managerial quality depends on the quality of employees promoted from the employee level and the quality of those hired from outside. The first term in (5) shows the effect of promotions. The second term summarizes the quality effects of hiring from the external labor market. As only well-performing agents are promoted, employees promoted from inside are better on average than managers hired from outside of the firm.

To solve the model, notice again that the promotion constraint (P) is binding in equilibrium. The firm would like to promote as many well-performing employees as possible to increase either firm profit or employee well-being as in the basic model. Furthermore, job assignment considerations are also calling for promotion of high performers instead of hiring untested outsiders into management. Promoting high-output employees improves the equilibrium composition of managerial rank through equation (5) in Lemma (2). On the other hand, increased promotions decrease employee composition by equation (4). However, the net effect of promoting high performers is positive because second-period managerial quality is more important than employee quality: $M(x) > F(x)$ and $M'(x) \geq F'(x) : \forall x \in [0,1]$. In sum, ports of entry prevail also in the job assignment model.

Furthermore, if the observed incentive mix prevails, then again the IR- and IC-constraints must bind. The logic is the same as in the basic model. Consequently, the observed incentive mix can only arise if all of the three constraints are binding. Assume for now and verify later that the observed incentive mix can arise. Given the binding constraints, the profit function can be expressed as a function of the layoff parameter (π_F). The profit-maximizing first order condition with respect to π_F can be expressed as:

$$\frac{\partial F}{\partial \mu_F}\mu(1-\mu)(\theta_G - \theta_B) = [1 - \theta_B - \mu(\theta_G - \theta_B) - \delta]\,(U_F + K) \tag{6}$$

The left-hand side of (6) summarizes the gains from layoffs. These gains are indirect and stem from improved employee quality in the second period. The term $\frac{\partial F}{\partial \mu_F} > 0$ shows that this indirect effect is positive. Thus, the positive effect is larger when employee heterogeneity is high, i.e., when both the quality differences ($\theta_G - \theta_B$) and the variance in workforce quality $\mu(1-\mu)$ is high.

The right-hand side of equation (6) summarizes the costs of layoffs. First, employees need compensation to join the workforce in order to offset expected job search costs U_F. Second, the firm incurs training costs K.

The first order condition shows that in the job assignment model layoffs are not necessarily set to zero. Hence, the observed incentive mix arises in the following case: First, the optimal firing rate implied by equation (6) is strictly positive (remember that promotion is necessarily positive by the binding P constraint). Second, the firm pays positive bonuses only if promotions and layoffs do not provide strong enough incentives. Third, the firm pays positive wages only

if the promotions, layoffs and bonuses do not compensate sufficiently for the outside job offer. Lemma (3) summarizes the conditions required for the observed incentive mix to arise.

Lemma 3 *In the job-assignment model the observed incentive mix of fixed wages, bonus payments, promotions, and layoffs arises in equilibrium if the following three conditions are satisfied: First, π'_F implied by (6) is strictly positive. Second, promotions implied by binding P:*

$$\pi_P^* = \frac{1}{H(\theta_B + \mu(\theta_G - \theta_B) + \delta)}$$

and $\pi_F^* = \min\{\pi'_F, 1\}$ does not provide enough incentives, so positive bonuses (b^*) are needed:

$$b^* = \frac{e}{\delta} - \pi_P^* U_P - \pi_F^* U_F > 0$$

Third, with π_P^*,π_F^*,b^* positive fixed wages (w^*) are required for employees to accept the contract

$$w^* = \bar{U} - (\theta_B + \mu(\theta_G - \theta_B))[b^* + \pi_P^* U_P] + (1 - \theta_B - \mu(\theta_G - \theta_B))\pi_F^* U_F > 0$$

The results in Lemma (3) are explicit about the hierarchy of incentives. In the job assignment model, promotions and layoffs are used first. If additional incentives are required, they are provided through bonuses. Finally, wages are used to make the employee accept the firm's offer.

3.2 The optimal use of layoffs

From the discussion above is becomes clear that firms benefits from layoffs if they face a heterogeneous workforce. However, there are two reasons why the firm may not be able to harvest these gains. First, the costs associated with turnover may exceed the benefits of employee sorting and selection. Second, government regulations may prevent layoffs. Both situations will reduce the profitability of the firm.

The gains from layoffs can be read directly from the left-hand side in the first order condition of the job-assignment model (equation (6)). First, the stronger long-run employee output (F) responds to quality improvements, the more the firm is interested in sorting and selecting its workforce. Second, the degree of employee heterogeneity adds to the benefits from layoffs. Intuitively, the more heterogeneous newly hired employees are, the more is to be gained from on-the-job sorting and selection.[5]

Variables on the right-hand side of (6) reduce the gains from layoffs. That is, the disutility of being fired (U_F) and turnover costs (K) have a negative effect on the layoff rate. This follows from the fact that the firm shoulders all the costs of turnover in equilibrium. Naturally, a reduction of these costs implies that the firm can benefit more from sorting and selection.

This discussion suggests that the gains from layoffs are particularly important when production is highly sensitive to the quality of the workforce and when employee heterogeneity is high. It also emphasizes that economic policy reducing the turnover costs and labor market frictions are beneficial to firms because both factors determine the extent to which firms can rely on sorting and selection. In addition, it should be stressed that highly regulated labor markets,

[5] Note that the heterogeneity measure $\mu(1-\mu)(\theta_G - \theta_B)$ is the first derivative of the second-period equilibrium employee quality (μ_F) with respect to the firing parameter (π_F).

where it is very costly or almost impossible to layoff employees, place firms in a disadvantaged situation when competing internationally because firms benefit from sorting and selection, even in situations where employment is stable.

3.3 The selection regime

The employment contract has profound implications for the firm's internal dynamics. The reason is that the conditional promotion and layoff probabilities (π_P and π_F) affect the workforce composition in the firm, as is established in Lemma (2). Furthermore, because high and low ability employees differ in their expected productivity, the ongoing sorting and selection (even beyond the second period) also affect the individual's employment prospects. In order to fully understand the consequences of sorting and selection, we will formally characterize the firm's selection regime and state conditions under which a particular selection regime will arise.

The contract implies that a proportion of the employees with high performance (who are more likely to be high ability employees) are promoted out of non-management each period. This will naturally imply that the quality of the group of employees passed over for promotion declines with tenure. We define this as negative selection on tenure. However, the picture may change if the firm lays off a sufficiently large proportion of employees with low performance (who are more likely to be low ability employees). In fact, if layoffs are used sufficiently frequent, the quality of the workforce in non-management will improve with tenure, and positive selection on tenure will arise. Thus, we make the following definitions:

Definition 2 (Selection) *When the quality of the workforce increases with tenure conditional on rank, the firm has positive selection on tenure. In contrast, when the quality of the workforce declines with tenure conditional on rank, the firm has negative selection on tenure.*

In addition to this, it should be recognized that if employee sorting is relevant, then it will only be optimal for the firm to promote employees with high performance. Hence, selection on rank is positive.

Selection on rank is unambiguously positive. Selection on tenure, however, can be either positive or negative. The outcome is determined by the frequency with which low performing employees are weeded out and high performing employees are promoted. The intuition is formalized in Lemma (4).

Lemma 4 *The firm has positive selection in rank. Selection on tenure is negative if*

$$\pi_P > \pi_F$$

and positive if

$$\pi_P < \pi_F$$

The close link between the selection regime and the employees careers' has been established in previous research, but the focus has exclusively been on negative selection, see Medoff and Abraham [1980, 1981], Lazear [1992], Gibbs [1995]. For instance, based on a series of empirical findings, Medoff and Abraham [1980, 1981] write "*... the negative within-grade-level correlation, which we suspect exists between experience and ability.*" Lazear [1992] continues this discussion, arguing that "*Individuals who remain on the job longer, do worse than those who are promoted*

out early. Wages actually decline with job tenure, probably reflecting the fall in the average worker's quality with length of time in the job." In terms of our model these statements can be interpreted as negative selection. A more detailed discussion is given in Gibbs [1995], who argues that "*... employees are continuously selected out through promotions, demotions, or exits. Because of these selection effects, ability of the group should decline with tenure...*" In contrast to the earlier examples, Gibbs recognizes that the selection process is affected by layoffs, but that does not change the result that selection on tenure is negative.

From this discussion it becomes clear that negative selection on tenure is a possibility, but not a rule. If the layoff probability exceeds the promotion probability, the selection scheme in tenure shifts from negative to positive. As it will turn out in the empirical analysis conducted below, our firm has a positive selection on tenure, which provides a counterexample to the earlier conclusions drawn about negative within-rank employee selection in the literature.

4 Empirical predictions

In this section we will derive the empirical predictions of the job assignment model. This is done in three steps. First, we show how the basic assumption of the model regarding employee sorting can be tested empirically. Second, an empirical strategy for identification of the firm's selection scheme is proposed. Finally, the model's broader predictions related to the employees' careers are stated.

4.1 Employee sorting

The key finding in the job assignment model is that the observed incentive mix is an optimal contract. This result relies strongly on the assumption that employee sorting contributes to overall profit. Furthermore, sorting should be based on performance because of the positive correlation between performance and unobserved employee ability. In particular, the firm should promote employees with high performance and lay off employees with low performance.

In order to test this hypothesis empirically, a measure of performance or a measure highly correlated with performance is required. In the empirical analysis conducted below, we use the information about bonus payments to establish if the employee had high performance, i.e., if a person received a bonus (b) during the preceding 12 months, the person must have had high performance. The power of using this measure over a performance scale created by subjective evaluation is that bonus payments induce costs on the firm. Thus, the firm will only signal high performance to the employees if it is indeed associated with high productivity. In contrast, firms may want to distort subjective performance evaluations without associated payments, see MacLeod [2003].

Using bonus payments as a measure for performance allows us to test the basic assumption of the model directly by estimating the effect of bonus payments on the promotion and layoff probabilities. From the model we know that the conditional probabilities are:

		Promotion	Layoff
Bonus payment	$(b = 1)$	π_P	0
No bonus payment	$(b = 0)$	0	π_F

This implies that the unconditional promotion and layoff probabilities for the high and low ability employees become:

$$\Pr(\text{Promotion}|j) = \Pr(b = 1|j)\pi_P = (\theta_j + \delta)\pi_P$$

and

$$\Pr(\text{Layoff}|j) = \Pr(b = 0|j)\pi_F = [1 - (\theta_j + \delta)]\,\pi_F.$$

Where $j = G, B$. Recall that μ_F is the proportion of high ability employees in non-management. Then we can write the probability of being promoted or laid off in a given period as:

$$\Pr(\text{Promotion}) = \mu_F\,[(\theta_G + \delta)\pi_P] + (1 - \mu_F)\,[(\theta_B + \delta)\pi_P]$$

and

$$\Pr(\text{Layoff}) = \mu_F\,[1 - (\theta_G + \delta)\pi_F] + (1 - \mu_F)\,[1 - (\theta_B + \delta)\pi_F]\,.$$

Naturally,

$$\frac{\Delta \Pr(\text{Promotion})}{\Delta b} > 0$$

and

$$\frac{\Delta \Pr(\text{Layoff})}{\Delta b} < 0.$$

Empirically we will use these cross-sectional relations to test for performance based sorting. Hence, the models first empirical prediction:

Predictions 1 (Sorting) *Sorting based on performance is a necessary condition for the observed incentive-mix of fixed wages, bonuses, promotions, and layoffs to be an optimal contract. In particular, under performance based sorting, employees with high performance are more likely to be selected for promotion, and employees with low performance are more likely to be laid off.*

4.2 Career dynamics

From the discussion above it is clear that performance based sorting strongly influences the evolution of the employees' careers. For instance, the firm is relatively more likely to select a high ability employee for promotion and to lay off low ability employees (recall that $\theta_G > \theta_B$). In Lemma (4) we established how these mechanisms will lead to a selection scheme which is either positive or negative on tenure. For instance, if the firm promotes high performing employees and layoffs occur sufficiently frequently, the quality of the workforce in non-management will increase with tenure, leading to a selection scheme which is positive in tenure. Negative selection on tenure occurs if the condition is reversed. Additional results about the selection on rank can also be established.

From Lemma (4) we know that the proportion of high ability employees with tenure depends on the conditional layoff and promotion probabilities:

$$\frac{\Delta \mu_F}{\Delta tenure} = \begin{cases} \geq 0 & \text{if } \pi_F \geq \pi_P \\ < 0 & \text{if } \pi_F < \pi_P \end{cases}$$

and that quality difference between management and non-management employees with similar levels of tenure is:

$$\mu_M - \mu_F > 0 \qquad \forall \pi_F, \pi_P \text{ and given tenure.}$$

Both results generalize to arbitrary levels of tenure and rank. This implies that we can identify the firm's selection scheme empirically by estimating the conditional promotion and layoff probabilities (π_P, π_F). Thus, our second empirical prediction:

Prediction 2 (Selection) *The firm has a positive selection on rank (conditional on tenure). Furthermore, it has a positive selection on tenure if and only if* $\pi_F \geq \pi_P$. *Otherwise, it has a negative selection on tenure.*

The firms selection scheme leads directly to predictions about the likelihood of receiving bonus payments. The cross-sectional probability of receiving a bonus payment for a non-management employee is:

$$\begin{aligned} \Pr(b &= 1) = \mu_F \left[(\theta_G + \delta)\right] + (1 - \mu_F) \left[(\theta_B + \delta)\right] \\ &= \mu_F(\theta_G - \theta_F) + \theta_F + \delta. \end{aligned}$$

thus,

$$\frac{\Delta \Pr(b = 1)}{\Delta tenure} = \frac{\Delta \mu_F}{\Delta tenure}(\theta_G - \theta_F).$$

From this it is clear that positive selection on tenure $\left(\frac{\Delta \mu_F}{\Delta tenure} > 0\right)$ implies that the cross-sectional probability of receiving a bonus payment increases with tenure. Negative selection would naturally have the opposite prediction. A similar argument applies to selection on rank:

$$\frac{\Delta \Pr(b = 1)}{\Delta rank} = (\mu_M - \mu_F)(\theta_G - \theta_F) > 0.$$

Thus, our final empirical prediction becomes:

Prediction 3 (Bonus)[6] *The probability of receiving a bonus depends positively on the employee's ability. Thus, the likelihood of receiving a bonus increases with rank (conditional on*

[6] The link between tenure and bonus payments lead to trivial predictions about earnings dynamics, i.e., positive selection on tenure will imply an increasing earnings profile even absent fixed wage growth. The issue of fixed wages and earnings dynamics is discussed in detail in section 7.

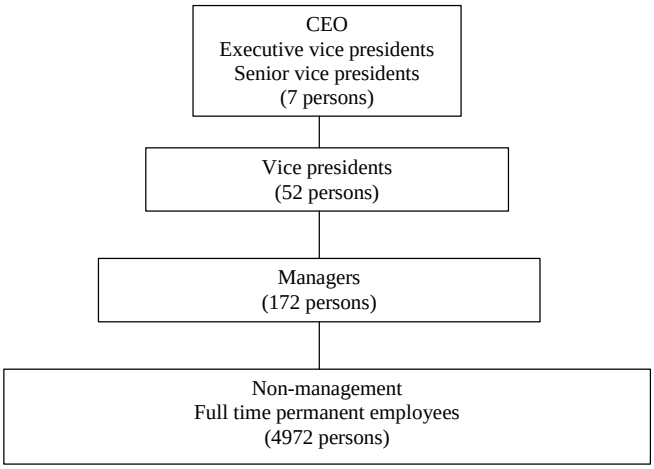

Figure 1: The hierarchy of the firm

tenure). Furthermore, the probability of receiving a bonus is increasing with tenure if and only if the firm has a positive selection on tenure.

It is important to stress that the predictions related to bonus payments are derived directly from the model's basic assumption on performance based sorting and the identified selection scheme. Hence, there is strong evidence for our model if the firm has performance based sorting and there is a match between the selection scheme and the cross-sectional relation between bonus payments and tenure. Alternatively, our model would be put into question if the data contradicts any of the predictions.

These predictions will be tested empirically below.

5 Data

Four years (1997 to 2000) of personnel records from the main production site of an international pharmaceutical company are used in the empirical analysis. The average employment level in the production site, which is stable over the period, is 5203 full time employees.[7] These workers are distributed across four hierarchical levels ranging from CEO to non-management, see Figure 1. The share of management workers in the firm is 4.44 percent.

The employees in the firm are divided into two groups: knowledge workers and production workers. The group of knowledge workers constitutes 66.20 percent of the workforce and will be used in the empirical analysis below. The contract offered to these workers contain the full incentive mix. Production workers are discarded from the analysis because they have no bonus options.

[7] The analysis is focused on permanent full-time employment, which corresponds to 90.45 percent of all individuals employed on the production site.

The employee characteristics are presented in the second and third columns of Table 2. Of the knowledge workers (column 3) 60.40 percent are women, and the average age is 39.55 years. The group has 8.91 years of tenure on average with a standard deviation of 7.43.

The level of education in the firm is high. In fact, 23.84 percent of the employees have at least a master's degree, and 12.19 percent have what corresponds to a bachelor's degree in duration. Only 13.65 percent of the labor force is unskilled.[8] There are three reasons why this structure is observed. First, the firm is operating in an industry where product development is essential for survival, which means that a large proportion of the workforce is engaged in research and development. Second, production is highly automated, suggesting that low-skilled labor has been substituted by capital. Finally, to comply with regulations from the Food and Drug Administration (FDA), extensive quality-control programs are implemented, requiring skilled labor.

	Mean (standard deviations)	
	All employees Observations = 19.239	Knowledge workers Observations = 12,737
Age	39.556	39.555
	(8.831)	(8.546)
Gender (women = 1)	0.589	0.604
Unskilled worker	0.136	0.034
Skilled worker	0.295	0.161
Short theoretical education	0.208	0.282
Bachelor's degree	0.122	0.169
Master's or PhD degree	0.238	0.353
Tenure: 2 years or less	0.201	0.190
Tenure: 3 to 5 years	0.148	0.145
Tenure: 5 to 10 years	0.307	0.288
Tenure: 10 to 15 years	0.169	0.185
Tenure: 15 to 25 years	0.139	0.144
Tenure: 25 years or above	0.037	0.049
Tenure	8.410	8.906
	(7.033)	(7.426)

Table 2: Descriptive statistics

5.1 The empirical contract and the theoretical assumptions

According to the firm's official remuneration principles, it offers wages to the employee such that: "*The base salary is a competitive pay for job function, responsibilities and competencies.*" The data provide evidence that this principle is taken seriously. For instance, a preliminary analysis of the fixed-wage component reveals that a set of individual characteristics and information about

[8] Information on education is missing for 7.44 percent of the employees. However, for the group of knowledge workers, only 2.57 percent have missing information on education.

the employee's job category predict wages precisely $\left(R^2 = 0.864\right)$.[9]

All knowledge workers are rewarded for performance through a bonus system. The allocation of bonuses fulfills the criteria that: "*The principles, criteria and targets that will lead to bonus payments should be known by the relevant employee subgroup.*" The size of the bonus pool varies across the different employee subgroups and constitutes 2.5 to 4 percent of the wage sum for non-management workers and 8 percent for non-executive managers.[10] The bonus system is widespread, and according to the data 24 percent of workers in non-management receive bonus payments within a given year. The numbers are closer to 75 and 80 percent for managers and vice presidents, respectively.

The hiring strategy of the firm is such that 98.33 percent of the employees are hired into the lowest hierarchical level. Thus, management vacancies are predominantly filled from within. This indicates that the firm has almost perfect ports of entry, which was also implied by the theoretical model, i.e., the binding P-constraint. The wage premium (unconditional on human capital) associated with a promotion from non-management and into lower- and middle-management is 44.23 and 75.96 percent, respectively. The policy of promoting from within and the associated wage gains upon promotion imply that the promotions option provides strong incentives for the employees.

The institutional settings impose no restrictions on who to lay off, and the firm seems to use layoffs frequently. The firm's yearly separation rate among its full time permanent employees is 5.98 percent. The turnover is costly for the firm, but nevertheless 20.35 percent of all separations are initiated by the firm through layoffs. The separation rate for knowledge workers is 6.72 percent. Of these, 18.77 percent are initiated by the firm. Thus, firing is a significant component of the observed incentive mix. The incentive effects of firing become clear from the firm's official wage strategy, which states that the firm intents to: "*Offer attractive salary and employment conditions*" in order to "*attract, develop and retain qualified employees.*" Given the "attractive" wages, the firm can use the threat of a layoff to motivate the workers.

It is of particular importance for this study that sorting and selection of the employees occur throughout the employment relation, i.e., the firm continues to promote and layoff employees beyond the first years of employment. For this reason, Figure 2 presents the layoffs and promotions that have taken place in the firm by tenure. It is clear from the figure that both layoffs and promotions occur at all levels of tenure. Naturally, they are most frequent at low tenure, where more employees are present. This suggests that sorting and selection is important at all tenure levels and that the incentive effects of promotions and layoffs are present even for employees with relatively high tenure.

In the presentation of the firm it becomes clear that the contract offered to the employees is highly complex in nature. First, the firm pays fixed wages to all workers who accept the contract, unconditional on performance. Second, 66 percent of the employees can be rewarded for performance through a bonus system. Third, even though turnover is costly for the firm, a significant part of separations are firm-initiated, i.e., layoffs. Finally, the firm has ports of entry, which implies that promotions to higher-level jobs take place (mainly) from the pool of incumbent employees. In sum, the data describes a contract that contains four incentive parameters: w, b,

[9] The regression is presented as model 1 in Table 8.

[10] The subsequent analysis is based on non-management employees, managers, and vice presidents. The executive management is omitted due to lack of data.

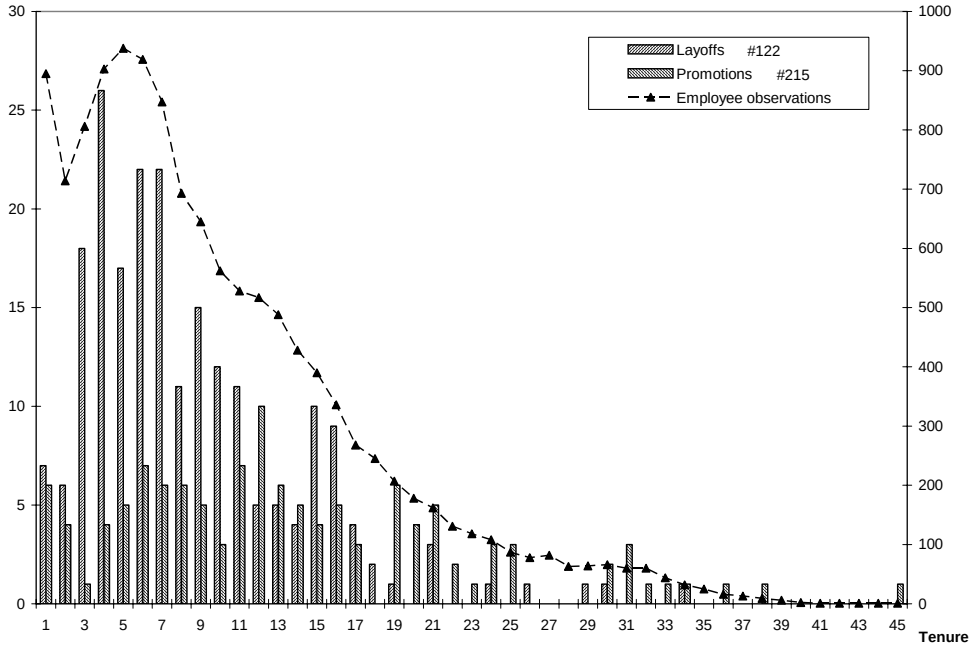

Figure 2: Layoffs and promotions

π_P, and π_F.

6 Empirical analysis

The predictions stated above are tested empirically in this section. A first goal is to establish that the firm has performance based sorting. According to the job-assignment model, this is a necessary condition for the observed incentive mix to be an optimal contract. Second, the firm's selection scheme is identified to be positive in rank and tenure. Finally, the model's broader predictions related to the employees' careers are tested.

Prediction (1) states that employee sorting based on performance is a necessary condition for the incentive mix to be an optimal contract. Preliminary evidence for sorting is found in the description of the empirical contract, where it is established that layoffs and promotions are common in the firm and used throughout the employees' careers. The presence of layoffs and promotions are necessary conditions for performance based sorting but are not sufficient because the decisions could be random. Thus, a first test for the presence of performance based sorting is to investigate if promotion and layoff decisions are based on information about employee performance. Following the discussion above, we use the information about bonus payments during the preceding year to indicate if an employee had high performance.

Promotions and layoffs are surprisingly difficult to predict; and in line with Prediction 1 only performance seems to matter. This becomes clear from the promotion and layoff regressions presented in Table 3. In the first model for promotions we include information about tenure

and education together with a large set of controls. Neither tenure nor the education dummies are significant. We tried various other specifications of the tenure effect (not shown), including linear-quadratic, and they remained insignificant. In the second promotion model we add an indicator for high performance, i.e., if the employee has received a bonus payment during the preceding year. In that regression the performance indicator is significant. Similar regressions are estimated for layoffs. As before, performance (or lack of high performance) seems to be the main predictor for a layoff. Thus, performance based sorting takes place in the firm.

	Logit models			
	Promotion regression (1)	**Promotion regression (2)**	**Layoff regression (3)**	**Layoff regression (4)**
Constant	**-5.273**	**-5.306**	**-10.471**	**-12.312**
	(2.660)	(2.668)	(2.141)	(2.207)
Bonus payment		**0.604**		**-2.157**
		(0.235)		(0.268)
Tenure	-0.029	-0.032	0.001	0.002
	(0.023)	(0.023)	(0.013)	(0.013)
Unskilled worker	-	-	-	-
Skilled worker	0.034	0.153	**-1.937**	**-1.867**
	(0.817)	(0.820)	(0.628)	(0.624)
Short theoretical education	-	-	-0.713	-0.605
	(-)	(-)	(0.528)	(0.512)
Bachelor's degree	-0.737	-0.642	0.508	0.665
	(0.716)	(0.721)	(0.465)	(0.452)
Master's or PhD degree	-0.699	-0.642	0.409	0.784
	(0.698)	(0.701)	(0.613)	(0.603)
Demographic variables	YES	YES	YES	YES
Job category	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
Log likelihood	-846	-842	-683	-645

Note: These regressions consider only transitions out of non-management. The models are estimated on monthly data, which is done to make optimal use of the available information on layoffs and promotions. In the period studied, no individuals with a short theoretical education were promoted. The demographic variables included are: age, age squared, and gender. Tenure squared is insignificant in all the models. Standard errors are clustered with respect to individuals.

Table 3: Promotion and layoff regressions for knowledge workers

Education may play a role for the likelihood of being promoted and laid off due to its positive correlation with ability. In the four-year period studied, no employees with a short theoretical education were promoted (and for that reason employees with this education level are dropped from the regressions). Skilled workers have a significantly lower probability of being laid off relative to the reference group of unskilled workers. The remaining indicators are highly insignificant. The large degree of imprecision in the estimates and the lack of any systematic variation due to education make it hard to draw any inference about the effect of education on the sorting and selection of employees. Therefore, we will not make any conclusion about this matter.

Prediction (2) stresses that the firm's selection scheme depends on the relative magnitude of the conditional promotion and layoff probabilities (π_P and π_F). We estimate the conditional

probabilities using a multinomial logit where the individual is facing three destinations: stay within rank, promotion, and layoff. Information about the conditional promotion and layoff probabilities are obtained by predicting the transition probabilities using the multinomial logit regression and conditioning on having received or not having received a bonus payment within the previous year, see Table 4.

	Destinations		
	Promotion	**Layoff**	**Stay within rank**
Average transition probability [sample means in brackets]	0.146 % [0.146 %]	0.101 % [0.101 %]	99.753 % [99.753 %]
Average transition probability given bonus is received.	0.166 %	0.027 %	
Average transition probability given no bonus is received.	0.091 %	0.231 %	
Change in probability due to bonus	0.075 %	- 0.204 %	

Table 4: Average predicted monthly transitions

In the multinomial logit regression the reference category is 'stay within rank'; and in line with the promotion and layoff regressions presented above, the dummy indicating a bonus payment is highly significant for both the promotion and layoff destinations. This implies that the average monthly promotion probability for employees who receive a bonus payment (i.e., those who had high performance) is 0.166 percent, while the layoff probability is as low as 0.027 percent. In contrast, the employees who did not receive a bonus payment (low performance) have little chance of being promoted and face a 0.231 percent risk of being laid off from the firm in any given month. Hence, a bonus payment increases the promotion probability by 0.075 percent and reduces the firing probability by 0.204 percent. These results expectedly support the findings related to Prediction 1 that the firm has performance based sorting.

From the results presented in Table 4 we can conclude that the average probability of being laid off conditional on not having received a bonus payment exceeds the promotion probability conditional on having received a bonus payment, i.e., $\pi_F = 0.231 > \pi_P = 0.166$. This allows us to conclude that the firm has a selection scheme which is positive in tenure.[11]

Prediction (3) follows from Prediction (2) and focuses on bonus payments. Given the firm has positive selection on tenure, Prediction (2) states that the probability of receiving a bonus payment increases with tenure. This prediction provides a strong test for the job assignment model as it combines fundamental aspects of the firms selection scheme with broader predictions about the employees' careers.

[11] Moreover, the positive selection might be even stronger than shown by these numbers due to a potential bias in the layoff data. A bias arises in the case where the firm signals to the worker that the employment relation will end in the near future. This signal will make the worker look for alternative employment, which may be obtained before the firm terminates the match. From conversations with the firm we have reason to believe that this procedure is common. The implication is that the layoffs observed in the firm only constitute a lower bound on the separations that in reality are layoffs.

Table 5 presents logit regressions for the probability of having received a bonus payment during the preceding year. In the first model, detailed tenure categories and information on employee rank are included together with a large set of controls. In accordance with predictions from positive selection, both tenure and rank have significantly positive and monotone effects on the probability of receiving bonuses.

	Logit model (1)	**Logit model (2)**
Constant	**-3.729**	**-4.288**
	(0.585)	(0.606)
Tenure: 2 years or less	-	-
Tenure: 3 to 5 years	**0.437**	**0.443**
	(0.095)	(0.095)
Tenure: 5 to 10 years	**0.460**	**0.474**
	(0.089)	(0.089)
Tenure: 10 to 15 years	**0.626**	**0.632**
	(0.101)	(0.101)
Tenure: 15 to 25 years	**0.699**	**0.722**
	(0.112)	(0.112)
Tenure: 25 years or above	**0.774**	**0.821**
	(0.154)	(0.154)
Non-management employees	-	-
Managers	**0.726**	**0.751**
	(0.183)	(0.183)
Vice presidents	**1.604**	**1.582**
	(0.491)	(0.491)
Unskilled worker		-
Skilled worker		0.226
		(0.149)
Short theoretical education		**0.450**
		(0.148)
Bachelor's degree		**0.463**
		(0.157)
Master's or PhD degree		**0.607**
		(0.179)
Demographic variables	YES	YES
Job category	YES	YES
Time dummies	YES	YES
Log likelihood	-5138	-5127

Note: Standard errors are clustered with respect to individuals. The demographic variables included are: age, age squared, and gender.

Table 5: Bonus regressions

In model 2 information on education is added. The positive relation between educational attainment and ability, and the increased production capacity of educated workers imply that workers with higher levels of schooling are more likely to receive bonus payments, see Becker [1964]. This result is confirmed by the data. However, it is important for the analysis to note that the positive effects of tenure and rank on the probability of receiving bonuses prevail. This indicates that ability is signaled only partially through education. Thus, sorting and selection

considerations are important, even though the level of formal schooling is observed.[12]

In Table 5 the positive relation between the probability of receiving a bonus payment and tenure is based on detailed tenure categories. The details come at a cost, namely that the dummies are estimated with relatively low precision. For this reason, we present an additional set of regressions where the dummies are substituted for linear and linear-quadratic tenure functions, see Table 6. In the first model, tenure is established to have a positive and relatively strong effect on bonus. Introducing a quadratic term indicates that the relation is inverted U-shaped. This result is, however, driven by the fact that few employees receive bonus payments during the first year of employment; and estimating the models for employees with more than one year of tenure, the quadratic term becomes insignificant, see column 4 and 5. Thus, the results show that positive selection on tenure prevails throughout the employees' careers.

	Logit model			
	No restrictions on tenure	No restrictions on tenure	Conditional on tenure > 1	Conditional on tenure > 1
Constant	**-3.790**	**-3.110**	**-3.569**	**-3.375**
	(0.577)	(0.607)	(0.602)	(0.633)
Tenure	**0.026**	**0.069**	**0.018**	**0.031**
	(0.005)	(0.013)	(0.005)	(0.014)
Tenure squared		**-0.001**		-0.000
		(0.000)		(0.000)
Education	YES	YES	YES	YES
Employee rank	YES	YES	YES	YES
Demographic variables	YES	YES	YES	YES
Job category	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
Log likelihood	-5,138	-5,130	-4,757	-4,756
# observations	9,019	9,019	8,493	8,493

Note: Standard errors are clustered with respect to individuals. The demographic variables included are: age, age squared and gender.

Table 6: Bonus regressions

6.1 Alternative hypothesis

Learning constitutes an alternative hypothesis to the sorting and selection hypothesis set forth by the job assignment model. In principle, learning could account for the positive relation between tenure and bonus payments established above if employees learn how to achieve high performance over time, i.e., the probability of receiving bonus payments increases (trivially) with tenure for a given individual. In other words, the sorting and selection hypothesis may be questioned if there is a positive relation between tenure and bonus payments conditional on employee ability.

In order to discriminate between the two hypothesis, we estimate a fixed-effects models for the probability of receiving a bonus payment. The point estimates of the set of tenure dummies

[12] The tenure effect identified in Table 5 could, in principle, be driven by the fact that managerial employees, who generally have longer tenure, are more likely to recieve bonuses. For this reason, model (2) has been estimated for non-management employees only. The results show that the tenure effect is robust.

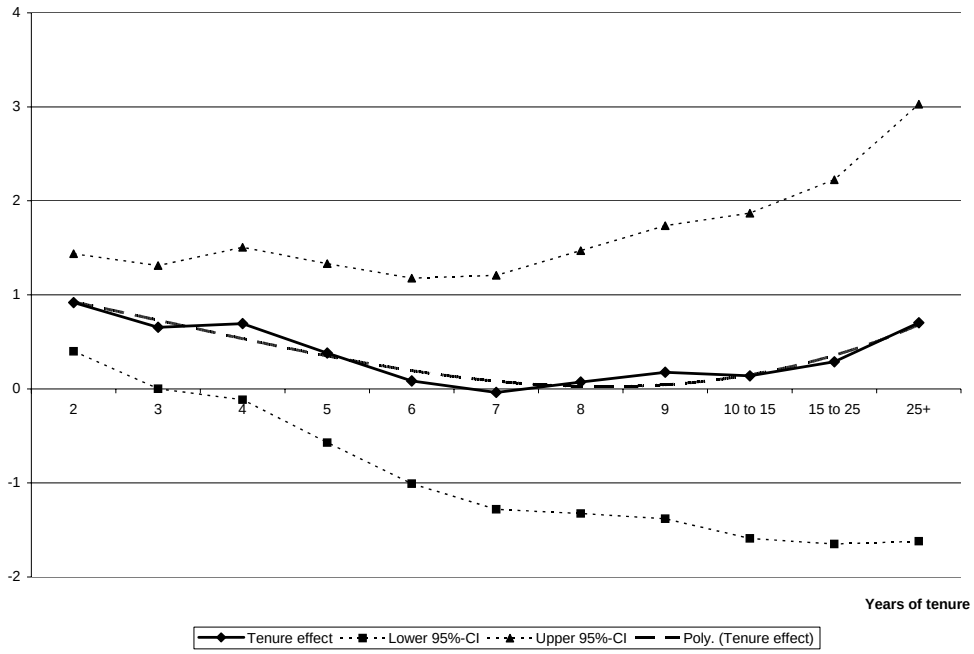

Figure 3: Fixed-effects model: The effect of tenure on the probability of receiving a bonus payment

(along with their pointwise 95% confidence intervals) are presented in Figure 3. The estimates are insignificant. Hence, conditional on unobserved ability, the effect of tenure on the probability of receiving a bonus payment is insignificant - at least it is not monotonically increasing. This indicates that the positive tenure profile established in the cross-sectional models are driven by sorting and selection, and not by learning.

7 Discussion

In their seminal work, Gibbons and Waldman [1999a,b] argue that: "*Any single (empirical) fact may be consistent with a variety of theories, so one way to choose among theories is by evaluating the extent to which each is consistent with a broad pattern of (empirical) evidence.*" In this paper, we have attempted to do exactly that.

To answer our initial research question of how the incentive mix observed in firms can be seen as an optimal contract, we proposed a job-assignment model. Within this context it becomes clear that the firm's concerns for workforce quality and it's interest in creating incentives for the employees provide the answer. This is a contribution in a theoretical sense, but according to the Gibbons and Waldman critique the true test of the model lies in its ability to predict additional empirical findings. For this reason, we conduct an empirical analysis, where evidence for sorting and selection is identified, and the model's broader predictions are tested. In general, there is a close fit between the model's predictions and the empirical evidence.

However, our model does not predict fixed wage dynamics. This suggests that the job-

assignment model should be extended by other building blocks in a larger integrative model, as suggested in Gibbons and Waldman [1999a,b]. In the following we discuss the empirical findings that an integrative model has to accommodate. Also, we explore possible theoretical explanations and provide suggestions for future research.

Table 8 presents a set of wage equations. In contrast to the standard case, these regressions include information on the firm's hierarchy. Thus, the results obtained reflect within-rank wage dynamics. Model 1 shows that the wage is increasing in the levels of education, tenure, and rank. Model 2 explores the effect of a bonus payment on current wages. The point estimate shows that employees who received a bonus payment during the preceding year (i.e., had high performance) have significantly higher current wages. An extension of this analysis is conducted in model 3, where information on the last two year's performance is included in the regression. Interestingly, both bonus dummies are significant. They also have similar effects on current wages. In the last model an interaction term for bonus in the preceding two years is included. This term is insignificant, reflecting that current wages are higher for those who receive bonuses, but the effect is not amplified above the level effect for those who receive bonuses on a continuous basis. These empirical observations are not easily explained by the job-assignment model, but a variety of other theoretical explanations provide possible explanations. Here, on-the-job human-capital acquisition, symmetric learning, and asymmetric learning with probabilistic outside offers are discussed.

The first potential explanation for the fixed wage dynamics is on-the-job human-capital acquisition. Gibbons and Waldman [1999a,b] show how on-the-job human-capital acquisition in conjunction with other building-block models (job assignment and learning) can be used to explain a large set of empirical evidence. The Gibbons-Waldman model distinguishes between the employees' innate ability, which can be high or low, and effective ability, which is a function of the employees' innate ability and labor-market experience. An assumption on symmetric information and steady changes in the employees' effective ability caused by continuous growth in labor-market experience leads to fixed-wage dynamics. Thus, on-the-job human-capital acquisition implies a simple, upward-sloping fixed-wage scheme for all workers. On-the-job human-capital acquisition, however, cannot explain without a stretch the significant and positive coefficient on bonus payments we observe in our data.

Second, symmetric learning, first investigated by Farber and Gibbons [1996], offers an alternative explanation. Under symmetric learning, outside firms can be expected to condition offers on the very same signals as the currently employing firm. In the context of the theoretical model and given the empirical evidence provided in Table 6, the relevant quality signals are education, bonus payments, survival in the firm, and promotions. As potential outside employers observe these signals, the employee's alternative option $\left(\bar{U}\right)$ becomes a function of the employee's perceived type. Raising $\bar{U}$ could, in principle, raise the fixed wage in order to secure that the participation constraint continues to be satisfied.

The third explanation is based on asymmetric learning with probabilistic outside offers. If outside firms cannot observe bonus payments within the firm, the firm might still want to increase the fixed wage for those employees who are more likely to be of high ability. Suppose, for instance, that outside firms are uncertain with respect to the worker's quality and give imprecise, probabilistic offers. Thus, good employees sometimes leave the firm for alternative jobs. Yet, if the firm learns about the type of the worker, it might increase the wages of those employees

who are likely to be of high ability. The reason for doing this is that the firm can reduce the probability of high-quality employees leaving the firm. Thus, probabilistic outside offers can also lead to wage increases in perceived type, as predicted above. The advantage of the probabilistic outside-offer explanation is that it does not necessarily require that the current firm and outside firms have the same information about employees.[13]

In sum, a variety of explanations are available to answer how signals create fixed-wage dynamics. These theories imply that our job-assignment model can be extended to capture wage dynamics. Yet, to step further more research is needed on firm-level data in order to evaluate the relative merits of the above theories. At this stage we can only say that wage dynamics can be made consistent with the model.

	(1)	**(2)**	**(3)**	**(4)**
Constant	**9.365**	**9.461**	**9.591**	**9.589**
	(0.035)	(0.037)	(0.041)	(0.041)
Bonus payment last year		**0.018**	**0.015**	**0.017**
		(0.002)	(0.003)	(0.003)
Bonus payment two years ago			**0.014**	**0.017**
			(0.003)	(0.005)
Bonus payment last year and two years ago				-0.005
				(0.006)
Tenure/10	**0.083**	**0.086**	**0.086**	**0.086**
	(0.006)	(0.008)	(0.009)	(0.004)
Tenure squared/100	**-0.015**	**-0.016**	**-0.016**	**-0.016**
	(0.002)	(0.002)	(0.003)	(0.003)
Unskilled worker	-	-	-	-
Skilled worker	**0.048**	**0.044**	**0.040**	**0.040**
	(0.010)	(0.010)	(0.011)	(0.011)
Short theoretical education	**0.066**	**0.060**	**0.052**	**0.052**
	(0.010)	(0.010)	(0.011)	(0.011)
Bachelor's degree	**0.078**	**0.074**	**0.072**	**0.072**
	(0.010)	(0.011)	(0.011)	(0.011)
Masters or PhD degree	**0.112**	**0.107**	**0.106**	**0.106**
	(0.011)	(0.011)	(0.012)	(0.012)
Non-management	-	-	-	-
Managers	-0.009	-0.013	-0.015	-0.015
	(0.007)	(0.007)	(0.008)	(0.008)
Vice presidents	**0.284**	**0.294**	**0.304**	**0.304**
	(0.014)	(0.015)	(0.016)	(0.016)
Demographic variables	YES	YES	YES	YES
Job category	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
R-squared	0.864	0.876	0.885	0.885
# observations	12,737	9,019	5,709	5,709

Note: Standard errors are clustered with respect to individuals. The lagged variables included in the regressions determine the number of observations used in the estimation. The demographic variables included are: age, age squared and gender.

Table 8: Log-wage regressions

[13] Asymmetric information could, in principle, lead to strategic rewards; that is, the current employer may give bonuses and promote strategically. The reason is that bonuses and promotions are signals to the market about the employee's quality. Waldman [1984] argues that these concerns may lead to inefficiencies.

8 Conclusion

Firms are known to offer highly complex incentive contracts to their employees. Such contracts most often contain fixed wages, bonus payments, promotions, and layoffs. In this paper, we aim at understanding why firms prefer such an incentive mix. In order to do so, we built a theoretical model and subsequently test it on personnel data. The key result is that firms with a production process that is sensitive to the quality of the workforce have an interest in using the full incentive mix. In particular, these firms use layoffs because it contributes to selection in addition to its incentive role.

This finding is important for two reasons. First, it shows that regulating layoffs has profound implications for firm profitability. The reason is that quality-concerned firms might want to layoff badly performing employees, even when the level of employment is constant, to improve the quality of their workforce. Thus, labor market regulations limiting layoffs might well place these quality-concerned firms in a comparative disadvantage when competing on the international market.

Second, this paper is used to refocus attention on layoffs in personnel economics by illustrating that layoffs have profound and unexpected consequences. For instance, it is shown theoretically that positive selection on tenure within a given rank is a possibility. This finding, which is supported by the data, challenges previous research in the area.

In addition, a hierarchy of incentives arises from the model. Firms with homogeneous employees or without quality concern would like to provide incentives through promotions and bonus payments; but not through layoffs. Promotions are preferred over bonuses because they use free residual incentives, such as managerial rent. This rent can be exploited through promotions to elicit effort from the lower ranks. In contrast, when firms are concerned about the quality and allocation of the workforce as is the case in the job-assignment model, the hierarchy of incentives is modified. The reason is that layoffs together with promotions contribute to sorting and selection of the employees; hence, layoffs becomes essential for profit maximization. Consequently, bonuses will only be used to provide additional incentives besides the ones given by promotion and firing.

Further, we use the optimal contract to derive predictions about the employee's career dynamics within the firm. These predictions describe the probability of receiving bonus payments, promotions, and layoffs for the individual employee. In the empirical analysis they are found to be consistent with the empirical evidence. The success in testing a broad set of predictions in addition to the single prediction of the incentive mix allows us to state that the paper accommodates the Gibbons and Waldman critique.

In conclusion, based on the discussion provided in this paper, we shed new light on employee incentives by investigating them in a joint empirical-theoretical framework. The results advance our understanding of the incentive role of layoffs in firms and its consequences for employee selection. Equally important, the paper paves the way for future research. In particular, adding other building blocks such as human capital acquisition and learning to the job-assignment model seems to be a fruitful way to improve our understanding of observed firm behavior.

9 Appendix

9.1 Proofs

Proof of Lemma (1). Notice that with binding constraints the profit is a function of the firing probability:

$$\begin{aligned}&(\theta+\delta)C+F-\overbrace{e+(\theta+\delta)\left[b+\frac{1}{H(\theta+\delta)}U_P\right]-(1-\theta-\delta)\pi_F U_F-\bar{U}}^{w}\\&-(\theta+\delta)b-\left[(1-\theta-\delta)\pi_F+\frac{1}{H}\right]K\end{aligned}$$

and that the bonus (b) is canceling out of the equation. Then, the first-order condition, in terms of the firing parameter can be written as:

$$-(1-\theta-\delta)(U_F+K)<0.$$

Thus, firing is minimized in equilibrium. ■

Proof of Lemma (2). Consider second-period employee quality (μ_F) first. Notice that establishing the volume of good quality employees determines employee quality because the firm employs a unit volume of employees. Thus, the equilibrium proportion can be determined as the sum of good employees newly hired into non-management and the number of good employees surviving to the second period.

$$\begin{aligned}\mu_F \;=\; &\overbrace{\underbrace{\mu[(1-\theta_B-\mu(\theta_G-\theta_B)-\delta)\,\pi_F+(\theta_B+\mu(\theta_G-\theta_B)+\delta)]}_{\#\text{ of goods newly hired}}}^{\#\text{ of newly hired}}\\&+\underbrace{\mu-(1-\theta_G-\delta)\mu\pi_F-(\theta_G+\delta)\mu\pi_P}_{\#\text{ of goods surviving}}\end{aligned}$$

Straightforward simplification yields the result in (4).

Managers are promoted either internally or externally. The quality of managers can be determined along a similar logic used above to determine employee quality. The number of good promoted employees should be divided by the number of managers ($1/H$). The number of internally promoted managers is given by:

$$\pi_P\mu(\theta_G+\delta)$$

Next, note that externally hired managers have an average quality μ. The volume of external hiring is given

$$\left(\frac{1}{H}-\pi_P(\mu\theta_G+(1-\mu)\theta_B+\delta)\right)$$

Thus, the volume of externally promoted good quality managers is:

$$\mu\left(\frac{1}{H}-\pi_P(\mu\theta_G+(1-\mu)\theta_B+\delta)\right)$$

Combining the terms yields the solution.

Finally, to see that μ_F is increasing in the firing rate, differentiate (4) with respect to π_F. ■

Proof of Lemma (3). The proof of the lemma follows from the discussion preceding it. It is straightforward to show parameter values where the incentive mix arises and is left to the reader. ■

Proof of Lemma (4). To see that selection on rank is positive, notice first that in equilibrium the promotion constraint is binding; then:

$$\mu_M = \frac{\mu(\theta_G + \delta)}{\theta_B + \mu(\theta_G - \theta_B) + \delta} \geq \mu + \mu(1-\mu)(\theta_G - \theta_B)(\pi_F - \pi_P) = \mu_F$$

which expression can be simplified to

$$1 \geq (\pi_F - \pi_P)\left(\theta_B + \mu(\theta_G - \theta_B) + \delta\right)$$

where both terms on the right-hand side are smaller than unity.

To see the statement of selection on tenure, focus on the employees staying in employee rank after the first period. The number of surviving employees is given by:

$$1 - \left(\theta_B + \mu(\theta_G - \theta_B) + \delta\right)\pi_P - (1 - \theta_B - \mu(\theta_G - \theta_B) - \delta)\pi_F$$

The number of surviving good ability employees is given by:

$$\mu\left[1 - (\theta_G + \delta)\pi_P - (1 - \theta_G - \delta)\pi_F\right]$$

Thus, the quality composition of tenured employees can be written as:

$$\mu_T = \mu \frac{1 - (\theta_G + \delta)\pi_P - (1 - \theta_G - \delta)\pi_F}{1 - \left(\theta_B + \mu(\theta_G - \theta_B) + \delta\right)\pi_P - (1 - \theta_B - \mu(\theta_G - \theta_B) - \delta)\pi_F}$$

and it can be rewritten as

$$\mu_T = \mu \frac{\overbrace{1 - (\theta_G + \delta)\pi_P - (1 - \theta_G - \delta)\pi_F}^{A}}{\underbrace{1 - (\theta_G + \delta)\pi_P - (1 - \theta_G - \delta)\pi_F}_{A} + (1-\mu)(\theta_G - \theta_B)(\pi_P - \pi_F)}$$

which is trivially higher than μ, if and only if $\pi_F > \pi_P$. ■

9.2 Managerial rent

In the model we assume that managerial rent exists; yet, we only handle it in a closed form. Here we provide some reasons for this closed-form representation. There are two major explanations, and both of them build on the same observation, namely that managers affect the work of many subordinates.

The first approach justifies rents by incentives. Calvo and Wellisz (1979) argue that rent is an increasing function of hierarchical rank. Their model is based on costly supervision, where shirking employees are punished by firing. This punishment, however, is only effective as long as there are rents with respect to the job. As managers affect the work of many subordinates, they are given more rents to ensure no shirking. Thus, the firm might be tempted to offer higher compensation for managers, even if the nature of the work is not different, and all the workers

and managers are identical. In sum, a wage (and rent) ladder might prevail, even absent quality differences.

The second rationale suggested here stems from the firm's desire to curb managerial turnover (more than the turnover of the non-management level). The intuition is simple, and again it rests on the observation that managers affect the output of many other employees. If a non-management employee leaves, it disrupts his own output. If a manager leaves, it disrupts the output of the manager and all his subordinates. Consequently, the firm would like to give stronger incentives to stay for managers than for workers. If outside offers are probabilistic, rents can be used to induce loyalty. Thus, in this setting the manager's compensation will include rents (strictly higher than those given to employees).

Finally, managerial rent has empirical support. It is generally understood that employees prefer to be promoted with the ongoing conditions. Thus, managerial work is more desirable, supporting the first incentive explanation. Also, voluntary managerial turnover is lower than voluntary employee turnover, which lends support to the second explanation.

In conclusion, we are comfortable with the closed-form modeling of managerial rents. The available empirical and theoretical evidence seems to support its existence.

9.3 Action-set conditioning

Conditioning the action set on output, as it was proposed in the model, is without the loss of generality.

In the basic model, the assumed action setup is general. The fact that the action set was constrained on output realizations does not change the equilibrium. It is straightforward to check that the firm would promote only high-performance employees and fire only low-performance ones. Similarly, the firm would not pay bonuses to low-performers, even if the action set would allow for that.

Under employee heterogeneity, the firm still prefers to promote well-performing employees and to lay off individuals with low performance. The reason is twofold. First, promoting well-performing employees and laying off badly performing ones is useful for incentive purposes. Second, selection considerations also strengthen the promotion and layoff policy. As managerial output is relatively more important than non-managerial output, better-quality employees are more desirable for promotion. Thus, as they are more likely to have high ability the firm prefers to promote high-performance individuals. Similarly, conditioning layoffs on low performance make sure that the fired individual is more likely to be of low ability. This improves the overall quality of the workforce, which has a positive impact on productivity. Again, it is straightforward to see that bonuses are only paid to well-performing agents, just like in the homogeneous case.

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