BONUSES AND PROMOTION TOURNAMENTS:

THEORY AND EVIDENCE

by

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ABSTRACT

Standard models of promotion tournaments do not distinguish between wages and bonuses and thus cannot be used to explain how the use of bonuses varies across workers and job levels inside a firm. In this paper we combine classic and market-based tournament theories to develop a promotion tournament model in which wages and bonuses serve distinctly different roles. We use this model to derive testable predictions which we then test employing data constructed from the personnel records of a medium-sized firm in the financial services industry. Our empirical analysis supports the testable predictions of our theoretical model and also shows that our theoretical approach provides a more complete picture of how bonuses vary across workers and job levels inside this firm than alternative theories of bonus determination based on arguments already in the literature.

I. INTRODUCTION

A seminal contribution in the personnel economics literature is the idea of promotion tournaments first put forth in Lazear and Rosen (1981). In this theory large wage increases are attached to promotions in order to achieve efficient effort levels for lower level workers. One drawback of the Lazear and Rosen approach, however, is that it makes no distinction between wage increases and bonuses and thus cannot be used to explain how bonus payments vary across workers and job levels inside a firm. In this paper we combine the classic approach to promotion tournaments pioneered by Lazear and Rosen with the market-based approach to promotion tournaments first analyzed in Gibbs (1995) and Zabojnik and Bernhardt (2001) to develop a theory concerning the role of bonuses in promotion tournaments.

In the classic approach to promotion tournaments pioneered by Lazear and Rosen (1981) each firm commits to a high wage associated with promotion, a low wage for workers not promoted, and also commits to promote the worker who produces more output. The result is that the high promotion wage serves as an incentive for effort and by optimally choosing the wage spread the firm induces low level workers to choose efficient effort levels. In contrast, in the market-based approach to promotion tournaments first explored in Gibbs (1995) and Zabojnik and Bernhardt (2001), firms do not commit to high promotion wages. Rather, building on Waldman (1984a), the promotion serves as a signal of high worker productivity. In turn, the signal results in high wage offers for promoted workers from prospective employers and the initial employer responds with a high promotion wage in order to stop promoted workers from being bid away. Like in classic tournament theory, the high wage serves to increase incentives for low level workers.[1]

In this paper we construct a model that combines features of the two approaches. Like in the market-based approach, firms cannot commit to the size of compensation increases associated with promotion, but rather the size of these increases is determined by the signal

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[1] See Prendergast (1999) and Lazear and Oyer (2012) for surveys that discuss the classic tournament approach and Waldman (2012,2013) for surveys that discuss both the classic and market-based approaches.

associated with promotion and the resulting higher compensation a promoted worker would receive by moving to an alternative employer. Like in the classic approach, on the other hand, we do allow firms to have some commitment ability in terms of compensation increases. In particular, at the beginning of each period each firm commits to a rate at which bonus size increases with worker output. In our model, as in earlier market-based tournament models, incentives provided through promotion prizes are frequently not first best. Thus, the role of the bonus is to augment promotion prizes so that aggregate incentives for effort are first best.

One empirically well documented finding concerning bonuses is that the size of bonus payments increases with job level (see, for example, Lambert, Larcker, and Weigelt (1993), Baker, Gibbs, and Holmstrom (1994a,b), and Smeets and Warzynski (2008)). However, the economic rationale behind this finding is not well understood. We show that our model captures this finding and, more generally, generates five testable predictions concerning how bonuses should vary across individuals and across jobs within a firm. These testable predictions are: i) controlling for age and job level tenure, bonus payments increase with job level; ii) controlling for job level and age, bonus payments increase with job level tenure; iii) controlling for job level, and job level tenure, bonus payments increase with worker age; iv) controlling for age, job level, and job level tenure, bonus payments increase with performance; and v) the bonus payment in the current period is negatively related to the expected prize associated with future promotion.

These five predictions all follow from the idea that in our model the firm always chooses the bonus rate that achieves efficient effort choices, where efficiency requires equality between the worker's marginal cost of effort and the marginal benefit associated with additional effort. This idea translates into our five testable predictions as follows. First, related to an argument in Rosen (1982), in our model the incremental productivity associated with additional effort increases with job level, so achieving efficient effort levels requires that the incremental compensation associated with additional effort also increases with job level. This is the primary driver of our first prediction that, holding job level tenure and age fixed, the size of bonuses increases with job level. Second, due to an assumption of task specific human capital, the increasing productivity associated with additional effort increases with job level tenure. So the bonus also increases with job level tenure. Third, because of the accumulation of general human capital as workers age, the increasing productivity associated with added effort increases with age and thus so do bonus payments. In addition, the reduction in promotion incentives as workers age also contributes to this result. Fourth, the prediction that bonus size rises with performance follows immediately as long as the bonus rate is positive which is the case in our model as long as promotion incentives are not too high. Fifth, if the expected prize for promotion rises, then bonus size must fall for overall incentives to remain at the efficient level.

In the second part of the paper we test these predictions using personnel data from a medium-sized firm in the financial services industry. This dataset was first employed in the classic study of Baker, Gibbs, and Holmstrom (1994a,b) that provides a detailed examination of wage and promotion dynamics at the firm.[2] The original dataset was a twenty-year unbalanced panel consisting of all managerial employees at the firm. We only employ the last seven years of the dataset in which bonus information is available. This seven-year panel is well suited for our purposes because in addition to having information on salary, bonus, and performance ratings, it also includes detailed information on the firm's job ladder that Baker, Gibbs, and Holmstrom constructed using the raw data on job titles and typical movements across job titles.

Our empirical analysis provides support for the model's predictions. Specifically, regression results show that the size of bonus payments increases with job level even when we control for age and job level tenure, the size of the bonus increases with job level tenure controlling for job level and age, the size of bonus payments increases with age for a large part of workers' careers after controlling for job level and job level tenure, and the size of the bonus payment also increases with performance after controlling for age, job level, and job level tenure. Consistent with the fifth prediction, we also find that an increase in the expected prize associated with promotion in the following period is negatively correlated with the size of the current

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[2] Other studies that employ this dataset include Gibbs (1995), DeVaro and Waldman (2012), and Kahn and Lange (2014).

bonus. In other words, as captured in our theoretical model, we find a trade-off between explicit incentives from bonuses and implicit incentives that arise from the tournament aspect of promotions.

Note that our empirical analysis suggests that the theoretical model developed in this paper better matches the data concerning how bonuses vary across job levels and individuals within firms than competing theories based on arguments already in the literature. One competing theory that builds on Rosen (1982) and Lemieux, MacLeod, and Parent (2009) is that bonuses are solely driven by how the return to effort varies across job levels, but this theory does not explain why bonuses at a given job level increase with worker age. Another competing theory based on the analysis in Gibbons and Murphy (1992) is that bonuses are solely driven by decreasing career concern incentives as workers age, but this theory does not explain why bonuses rise with job level after controlling for worker age. And neither of these alternative theories explains our findings of a positive correlation between bonus size and job level tenure and a negative correlation between bonus size and promotion based rewards.

The outline for the paper is as follows. Section II discusses related literature. Section III presents our model and some preliminary results. Section IV presents an analysis of the full equilibrium of the model and discusses testable predictions. Section V describes the data we use in our empirical analysis. Section VI begins with a preliminary empirical analysis of the firm's bonus policy and then presents our investigation of the model's testable predictions. Section VII presents concluding remarks.

II. RELATED LITERATURE

As briefly discussed in the Introduction, our paper falls into the extensive literature on promotion tournaments which started with the seminal contribution of Lazear and Rosen (1981).[3] All of the early literature on the subject assumes that the incentive effects of promotions stem

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[3] Other early papers in this literature include Green and Stokey (1983), Nalebuff and Stiglitz (1983), Malcomson (1984), and O'Keefe, Viscusi and Zeckhauser (1984).

from an ability of firms to commit to future compensation levels. That is, firms commit to high levels of compensation for promoted workers and lower levels for workers not promoted and then workers compete for promotion prizes typically through the choice of effort levels. This literature considers a variety of analyses which include comparing promotion tournaments with other ways of compensating workers, deriving the properties of equilibrium promotion tournaments under various assumptions concerning worker heterogeneity, the nature of the production environment, etc., and considering multi-stage promotion tournaments.

A more recent literature that has come to be called the market-based approach assumes that commitment is not possible, but rather promotion prizes arise due to the signaling role of promotions first explored in Waldman (1984a). The basic argument, first put forth in Gibbs (1995) and Zabojnik and Bernhardt (2001), is that firms pay promoted workers high promotion wages in order to stop promoted workers from being bid away when the positive signal associated with promotion results in prospective employers increasing their wage offers.[4] In turn, like in the Lazear and Rosen approach, workers respond to the high promotion wages by increasing effort or investing more in the development of human capital.[5]

Our model combines elements of each of these two approaches. We allow firms some commitment ability in terms of compensation – in each period firms commit to a minimum output required to receive a bonus and a bonus rate for that period. However, like in the market-based approach, firms cannot commit to compensation levels for future periods and promotion

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[4] See Ghosh and Waldman (2010), Zabojnik (2012), and Guertler and Guertler (Forthcoming) for more recent papers that take this approach.

[5] A small literature has developed that focuses on whether real world promotion tournaments are better described by the classic approach put forth by Lazear and Rosen (1981) or the more recently developed market-based approach. Waldman (2013) surveys the empirical literature and argues that the evidence is mixed concerning whether it is more consistent with the classic approach or the market-based approach. He concludes by arguing that a hybrid approach that combines the two approaches which is similar to the approach we pursue might be more consistent with the evidence than either of the two approaches taken in their pure forms. Wang (2013) focuses on predictions concerning how promotions affect turnover and, based on an empirical analysis of the Baker, Gibbs, and Holmstrom (1994a,b) dataset, argues that the market-based approach does a better job of explaining the evidence at low levels of the job ladder and the classic approach does a better job at high levels. In contrast, DeVaro and Kauhanen (Forthcoming) provide empirical tests based on how worker and firm behavior changes when the stochastic component of worker performance becomes more important. They find that the classic approach does best at matching results based on this set of tests.

prizes arise due to the signaling role of promotion rather than commitment. Further, different than both approaches, our focus is on the role and size of bonuses in promotion tournament settings which has drawn little prior attention in this literature.[6]

Although not promotion tournament models, the paper also builds on Rosen (1982), Gibbons and Murphy (1992), and Lemieux, MacLeod, and Parent (2009). Gibbons and Murphy extend the career concerns argument of Holmstrom (1999) (see also Fama (1980)) to consider how performance pay should vary over a worker's career. The basic argument is that as a worker gets older incentives provided through the symmetric learning mechanism identified by Holmstrom should decrease. This occurs both because of fewer periods remaining in the worker's career to reap any return from improved beliefs concerning the worker's ability and because there is less remaining uncertainty concerning the worker's ability. As a result, to keep incentives high as workers age, firms must increase pay for performance. After developing the theory, Gibbons and Murphy show supporting evidence using data on CEO compensation.

Our argument is related in that we also focus on trade-offs between different avenues through which incentives are provided, although the specific avenues considered are different across the two papers. Gibbons and Murphy (1992) focus on career concern incentives and performance pay (bonuses are a type of performance pay), while our focus is promotion incentives and bonuses. Further, in addition to this difference in focus, there are a number of other important differences. First, they assume firms learn about worker ability after they enter the labor market in a symmetric fashion which means that all firms have the same information about each worker's ability at any point in time. In contrast, we assume this learning is

[6] There are a few earlier papers that consider the possibility of a trade-off between promotion-based incentives and bonuses. Gibbs (1995) and Boschmans (2008) both provide theoretical analyses that capture the basic trade-off, although neither provides results similar to any of our other testable predictions. Gibbs also provides empirical testing but finds no evidence of a trade-off between promotion-based incentives and bonuses, while Boschmans provides no empirical testing. Ortin-Angel and Salas-Fumas (1998) provides an empirical investigation of bonuses in a sample of top and middle managers at Spanish firms and finds a number of results some of which they interpret as evidence of a trade-off between promotion-based incentives and bonuses. But they do not test for the trade-off directly and their findings, such as that bonuses rise with job level, have alternative explanations. Also, Krakel and Schottner (2008) consider a theoretical model characterized by promotion tournaments and bonuses, but their model does not capture the trade-off between promotion-based incentives and bonuses.

asymmetric which means that a worker's current employer is better informed. Second, they assume a single job at which a worker remains throughout his or her career, while we assume a job ladder that workers climb as they gain labor market experience and show evidence of superior ability through successful performance. Third, in addition to a prediction similar to the Gibbons and Murphy prediction concerning how pay for performance varies with worker age, we derive testable predictions concerning bonus size, job level, job level tenure, and promotion incentives not analogous to anything found in that earlier paper.

Lemieux, MacLeod, and Parent (2009) show how the prevalence of pay for performance affects wage inequality. Although not their main focus, their theoretical model suggests a potential explanation for why bonuses increase with job level. That is, in their model the size of performance pay at a job depends positively on the returns to effort at that job. Combining this idea with the one found in Rosen (1982) that returns to effort are higher at higher job levels yields the prediction that the performance pay component of compensation contracts should be larger at higher levels of a firm's job ladder.[7] We incorporate this idea into our model and it is an important driving force behind our testable predictions.

Note that Gibbons and Murphy (1992) and the combination of Rosen (1982) and Lemieux, MacLeod, and Parent (2009) are two alternative explanations for why bonuses rise with job level. First, in the Gibbons and Murphy (1992) argument bonuses are predicted to rise with job level because, on average, workers on higher job levels are older. Thus, in that argument, holding worker age fixed, bonuses are independent of job level, but bonuses should rise with age holding job level fixed. Second, in the combined argument of Rosen (1982) and Lemieux, MacLeod, and Parent (2009) bonuses rise with job level because the return to worker effort rises with job level. In this argument bonuses should rise with job level even holding worker age fixed, but bonuses are predicted to be independent of worker age holding job level

[7] To be precise, in Rosen (1982) returns to worker ability are higher at higher job levels (see also Waldman (1984b)). But if productivity is a function of ability plus effort (which is what we assume in our theoretical analysis) or ability times effort, then returns to worker ability rising with job level will also translate into returns to worker effort rising with job level.

fixed. In our argument, in contrast, bonuses rise with job level holding worker age fixed and rise with age holding job level fixed. Further, our model predicts a positive correlation between job level tenure and bonus size and also a trade-off between bonus incentives and promotion incentives. Neither of these additional predictions is generated by these alternative theories.

Our assumption that the labor market is characterized by asymmetric learning and promotion signaling is supported by a number of empirical studies. Gibbons and Katz (1991) was the first paper to empirically test for asymmetric learning in labor markets. Their focus was Greenwald's (1986) adverse selection argument concerning labor market turnover and its implications for differences between laid off workers and those fired in a plant closing. Using the Current Population Survey, they find support for the adverse selection argument. Further, a number of more recent papers including Schoenberg (2007), Pinkston (2009), and Kahn (2013) take alternative approaches to test for asymmetric learning and, in general, these more recent papers also find evidence consistent with asymmetric learning being important.[8]

There are also papers that directly consider the promotion-as-signal hypothesis. Most of these papers focus on tests derived from the basic idea first put forth in Bernhardt (1995) that the signal associated with promotion should be smaller for workers in higher education groups, so workers in these groups should be favored in the promotion process. The papers that take this approach such as Belzil and Bognanno (2010), DeVaro and Waldman (2012), Cassidy, DeVaro, and Kauhanen (2015), and Bognanno and Melero (Forthcoming) mostly find evidence that supports the hypothesis.[9]

We also assume that the production process is characterized by task-specific human capital which is the focus of a number of recent theoretical and empirical papers. The basic definition of task-specific human capital and discussions of various potential applications can be

[8] Of these more recent papers, Schoenberg's is the only one that finds weak evidence for asymmetric learning. But as is argued in Waldman (2012), it is unclear that the test for which she finds weak evidence for asymmetric learning is in fact a valid test of the asymmetric learning argument.

[9] Gibbs (2003) employs alternative tests of the promotion signaling hypothesis that do not depend on how promotion signals vary with education and he also finds evidence that supports the hypothesis.

found in Gibbons and Waldman (2004,2006). Empirical studies that support the task-specific human capital argument include Gathmann and Schoenberg (2010), Devereux et al. (2013), and Schulz et al. (2013). The first of these papers focuses on the turnover decision, while the other two are closer to our study in that they show how compensation varies with job level tenure.

The paper is also related to a well known puzzle identified by Baker, Jensen, and Murphy (1988). That paper asked, why is it that incentives are provided through promotions rather than solely through bonuses and other non-promotion based compensation increases? That is, if promotions are used to both assign workers to jobs and provide incentives, then inefficiencies will result because the two roles will sometimes be in conflict. So, according to Baker, Jensen, and Murphy, it would be more efficient to use promotions solely for assignment and use non-promotion based compensation changes to provide incentives. The market-based approach to promotion tournaments provides an answer to this puzzle. Specifically, the signaling role of promotions causes promotions to be associated with large wage increases, so firms are in a sense forced to employ promotions as an incentive device. In this paper we extend this argument to consider how the provision of incentives are divided between bonuses and promotion-based incentives when promotions serve as signals.

III. MODEL AND PRELIMINARY ANALYSIS

In this section we present our model of promotion and bonus incentives in a hierarchical model of production, and then present some preliminary results.[10] In the next section we present a full equilibrium analysis and also present and discuss testable implications. Note that the specific model we consider builds on an analysis in Ghosh and Waldman (2010).

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[10] In the model we construct and analyze there is no requirement that only a single worker or some fixed number of workers is promoted. So one might argue that this is not a promotion tournament model. Following Waldman (2013), we are defining promotion tournaments as settings where promotions serve an incentive role because of promotion wage increases whether or not there is a requirement that only a single worker or a fixed number of workers is promoted. See Waldman (2013) for further discussion.

A) The Model

We consider a two-period model with free entry and identical firms that produce output using labor as the only input. Workers live two periods, where a worker is referred to as young in period 1 and old in period 2. Worker i's innate ability is denoted θ_i, where there are two groups of workers denoted groups 1 and 2. The value for θ_i for a worker in group k is a random draw from the probability distribution function $F_\theta^k(.)$ which is uniform with support $[\theta_k^L,\theta_k^H]$, where $\theta_2^H-\theta_2^L\geq\theta_1^H-\theta_1^L>0$ and $E(\theta^k)$ denotes the unconditional expected value for θ for a worker in group k. None of the labor market participants including the worker knows a worker's true value for θ_i at the beginning of the game but a worker's group as well as the distributions $F_\theta^1(.)$ and $F_\theta^2(.)$ are common knowledge. The asymmetric information structure of the model determines how firms learn about worker ability. A worker's current employer and the worker privately observe the worker's output realization at the end of each period and use that information to revise beliefs about the worker's ability. The firm then uses this additional information in deciding whether or not to promote the worker and then prospective employers use the promotion decision as a signal of ability.

Each firm has three job levels, denoted 1, 2, and 3. If worker i is assigned to job j, j=1,2, or 3, in period t, then the worker produces $y_{ijt}=s_{it}(c_j+d_j(\theta_i+e_{it}))-z_{ijt}$, where s_{it} is worker i's human capital in period t which is defined in detail below, e_{it}, $e_{it}\geq 0$, is worker i's effort in period t, and z_{ijt} represents a training cost which is also described in detail below. Note that, given no stochastic element in the production process, at the end of the first period in any pure strategy Nash equilibrium each firm learns with certainty the innate ability levels of its period 1 employees. Introducing a stochastic element would complicate the analysis, but would not change the basic nature of the results.

Starting with Rosen (1982), it is standard to assume that the incremental productivity associated with ability (and effort) increases with job level and that it is efficient to assign low ability workers to low levels of the job ladder and high ability workers to high levels of the job ladder. To make the model consistent with these standard conditions we assume $d_3>d_2>d_1>0$ and $0<c_3<c_2<c_1$. Also, additional related assumptions are imposed below.

As indicated, s_{it} is worker i's human capital in period t. For all young workers s_{it} equals one. If worker i does not switch firms at the beginning of period 2, then $s_{i2}=s_1$ if this is the worker's first period at the worker's current job level and $s_{i2}=s_2$ if it is the second period on the current level, where $s_2>s_1>1$. If at the beginning of period 2 this worker moves to a new firm, then $s_{i2}=h_1$ if this is the worker's first period at the worker's current job level and $s_{i2}=h_2$ if it is the second period on the current level, where $h_2>h_1>1$, $s_2>h_2$, and $s_1>h_1$. In other words, in our model there is general, firm specific, and task specific human capital. General human capital is measured by h_1-1, while firm specific human capital is captured by the differences s_1-h_1 and s_2-h_2. The task specific human capital some of which is also firm specific is captured by the differences s_2-s_1 and h_2-h_1. As discussed in Gibbons and Waldman (2004), task specific human capital can be thought of as the accumulation of human capital which is partially or fully lost when a workers switches tasks, which we capture by a switch in the job level. Note that a worker can accumulate general, firm specific, and task specific human capital either through learning-by-doing or on-the-job training. Since it is not our focus, the exact mechanism through which workers accumulate the various types of human capital that we assume is not modeled.

We also assume $s_1d_{k+1}>s_2d_k$ and $h_1d_{k+1}>h_2d_k$ for all k, k=1,2. Since our focus will be on parameterizations such that group k workers are on job k in period 1, these assumptions tell us that for old workers productivity rises faster with innate ability after a promotion. The role of these assumptions is to help ensure that firms have an incentive to place workers with higher innate ability at higher levels of the job ladder. Additionally, $s_1d_{k+1}-s_2d_k>h_1d_{k+1}-h_2d_k$ for all k, k=1,2. This assumption states that the net increase in productivity associated with promotion rises faster with innate ability when the promotion does not include a move between firms. This assumption also helps ensure that firms promote higher innate ability workers.

As indicated, z_{ijt} is a training cost worker i incurs if assigned to job j in period t. Specifically, there is a positive training cost the first period a worker is at a firm and the second period a worker is at a firm but it is the first period at the current job level. So z_{ijt}=z, z>0, if t=1, z_{ijt}=z if t=2 and worker i was not on job level j in period 1, and z_{ijt}=z if t=2 and worker i is at a new firm in period 2. Otherwise, z_{ijt}=0. Note that we further assume c_1>z which ensures that output is always positive.

We assume that employers cannot offer long-term contracts, i.e., they cannot commit to future wages or promotion decisions in subsequent periods. Also, prospective employers do not observe salaries paid or bonuses. In order to capture the interaction between the size of bonus payments and promotion incentives, we also assume that output is contractible but not publicly observable.[11] To be specific, in each period t, t=1,2, firms offer workers compensation contracts consisting of a base salary, α, a minimum output level, y^M, and a bonus rate, β, where the bonus payment is the bonus rate multiplied by the difference between the worker's output and the minimum output level specified in the contract.

Firms and workers are assumed to be risk neutral and both have a discount factor equal to δ, where δ is sufficiently small that the bonus rate is always positive. Further, worker utility is given in equation (1).

$$(1)\qquad U(w_1,w_2,e_1,e_2)=\sum_{t=1}^{2} \delta^{t-1}U_t(w_t-g(e_t))= \sum_{t=1}^{2} \delta^{t-1}(w_t-g(e_t))$$

In this equation w_t is the worker's wage in period t (salary plus bonus), e_t is the period t effort level, and $g(e_t)$ is the disutility of effort. We further assume g(0)=0, g′(0)=0, g′(e)>0 and g′′(e)>0 for all e>0. Let $e_j*(s_{it})$, j=1,2, be the efficient effort choice for worker i in period t assigned to job j. Given the specification for production and worker utility described above, $e_j*(s_{it})$ satisfies $s_{it}d_j=g'(e_j*(s_{it}))$ for j=1,2, and 3.[12]

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[11] In other words, the employer can credibly reveal a worker's output to the courts but that output is not observable to prospective employers. See Mukherjee (2008) and Koch and Peyrache (2009) for recent papers that employ this approach. An alternative approach taken by some authors is to assume that a supervisor, whose responsibility includes assessing worker performance, can bias assessments in order to misallocate monetary rewards. See, for example, Milgrom and Roberts (1988), Prendergast and Topel (1996), and Fairburn and Malcomson (2001) for related analyses.

[12] We further assume g(e)=γh(e), where h(e) satisfies the same conditions as g(e) and γ>0 but sufficiently small that in equilibrium firms always have an incentive to promote higher ability workers.

The sequence of moves in the game is as follows. At the beginning of period 1 firms make period 1 contract offers and workers choose firms based on utility maximization. Workers are then assigned to jobs and each worker chooses an effort level. Then output is produced, privately observed by the first period employer and the worker, and then the worker is paid. Based on the output realization, each worker's first period employer updates its beliefs regarding the worker's ability and then, at the beginning of period 2, assigns the worker to a job. Prospective employers, which observe neither effort nor output, use the job assignment as a signal of ability and make offers consisting of a compensation contract and job assignment.[13] Then each worker's current employer is allowed to make a counter-offer concerning the compensation contract. Each worker then chooses a firm, chooses a second period effort level, second period output is realized, and the worker is paid.

Our focus is on pure strategy Perfect Bayesian equilibria where beliefs concerning off-the-equilibrium path actions are consistent with each such action being taken by the type with the smallest cost of choosing that action. This assumption concerning off-the-equilibrium path actions is similar to the notion of a Proper Equilibrium first discussed in Myerson (1978). Also, in our model there are multiple equilibria that are identical except for how compensation is divided between salary and bonus because of differences in y^M. We focus on the equilibrium where the lower bound on the bonus always equals zero since this best matches the dataset we analyze in our empirical analysis.[14]

B) <u>Preliminary Analysis</u>

Because one of our goals is deriving how the bonus varies with job level holding age fixed, we restrict the analysis to parameterizations such that group 1 workers are assigned to job

[13] An alternative approach is to allow firms to offer a menu of contracts and job assignments similar to the approach taken in Ricart i Costa (1988). Our results are not robust to this change, but results would be similar if in addition to allowing such a menu we also introduced a training cost associated with subsequent promotion that is borne by the first period employer at the end of the first period.

[14] Period 2 compensation contracts are individual specific so y^M is set such that the bonus equals zero if zero effort is chosen by the individual. For period 1 there is a single compensation contract for each group, so y^M for group k is set so the bonus equals zero if innate ability equals θ_k^L and effort equals zero.

1 in period 1 and group 2 workers are assigned to job 2 in period 1. Also, to simplify the analysis we focus on parameterizations such that in period 2 a worker is either kept at the same job level or promoted one level, i.e., the probability of being promoted two job levels or being demoted both equal zero. And we assume parameters are such that the probabilities of promotion are below the efficient levels which is the standard case in promotion signaling models. See the Appendix for details.

In the rest of this section we analyze how the model works period by period, where we start with period 2 and then consider period 1. In the next section we describe the full equilibrium of the model and discuss testable implications.

As indicated, we begin with period 2. Because of firm specific human capital, there is no turnover.[15] The contracting problems each firm faces in period 2 are standard contracting problems in which a firm chooses a salary, a minimum output level, and a bonus rate to maximize period 2 profits subject to participation and incentive compatibility constraints. Lemma 1 characterizes the solution to these maximization problems. Below let e_{ijk2} be the equilibrium effort choice of worker i in group k assigned to job j in period 2, α_{ijk2} be the worker's salary, $y_{ijk2}{}^{M}$ be the minimum output specified in the worker's contract, β_{ijk2} be the bonus rate, z_{ijk2} be the training cost, and y_{ijk2} be the worker's output. Also, let θ_{ijk2} be the innate ability level of worker i in group k assigned to job j in period 2 and $U^{2M}(\theta_{ijk2})$ be the utility that worker i in group k assigned to job j by the worker's first period employer would receive by moving to a new firm at the beginning of period 2.

Lemma 1: Equilibrium period 2 compensation contracts and effort levels satisfy i) through iii).

i) β_{ijk2}=1 and e_{ijk2}=e_j*(s_2) for every worker i in group k, k=1,2, assigned to job k in period 2 at the worker's first period employer, i.e., j=k.

[15] If we introduced turnover, then we could derive predictions concerning how bonus size varies with firm tenure. We do not take this step because the dataset we employ in our empirical analysis has noisy data concerning firm tenure due to the dataset only including the managerial part of the workforce.

ii) β_{ijk2}=1 and $e_{ijk2}=e_j^*(s_1)$ for every worker i in group k, k=1,2, assigned to job k+1 in period 2 at the worker's first period employer, i.e., j=k+1.

iii) $y_{ijk2}^M=s_{k-j+2}(c_j+d_j\theta_{ijk2})-z_{ijk2}$ and $\alpha_{ijk2}+(y_{ijk2}-y_{ijk2}^M)-g(e_{ijk2})=U^{2M}(\theta_{ijk2})$ for every worker i in group k assigned to job j in period 2, k=1,2 and j=k,k+1.

Lemma 1 tells us that an equilibrium compensation contract in period 2 works quite simply. The contract induces the efficient effort level where the efficient effort level equates the marginal benefit of increased effort with the marginal cost of effort. This is captured in i) and ii), where in period 2 the firm always equates the marginal benefit of increased effort with the marginal cost of effort by setting the bonus rate equal to one. Note that, since period 2 is the last period, there are no promotion incentives driving effort choices in period 2, so the bonus rate is set such that a worker receives the full extra productivity associated with an increase in effort.

The other aspect of Lemma 1 is the determination of period 2 salaries and minimum output levels captured in iii). As mentioned earlier, we assume there is firm specific human capital so there is no turnover in this model and we also assume that the lower bound on the bonus equals zero. This means two things in equilibrium. First, a worker's minimum output level is what the worker produces given zero effort. Second, the first period employer chooses a compensation contract for each worker such that the worker's utility associated with staying just equals the utility associated with the worker moving to a new firm.

Now consider period 1. At the beginning of period 1 workers within each group look identical and so there are two compensation contracts offered to first period workers – a group 1 contract and a group 2 contract. In particular, the equilibrium first period compensation contracts are the ones that maximize expected worker utility over the two periods subject to an incentive compatibility constraint and a non-negative expected profit constraint. The logic is that competition between firms for workers at the beginning of the first period results in the equilibrium contracts being the ones that maximize expected worker utility subject to firms not losing money. Further, in equilibrium the non-negative expected profit constraint is binding so the equilibrium contract for each worker group is the one that maximizes expected worker utility subject to a zero expected profit constraint.

Let e_{ijk1} be the equilibrium effort choice of worker i in group k assigned to job j in period 1, α_{ijk1} be the worker's salary, y_{ijk1}^M be the minimum output specified in the worker's contract, β_{ijk1} be the bonus rate, and y_{ijk1} be the worker's output. Remember, the analysis is restricted to parameterizations such that group 1 workers are assigned to job 1 in period 1 and group 2 workers are assigned to job 2. Lemma 2 characterizes the solutions to these first period maximization problems.

Lemma 2: Equilibrium period 1 compensation contracts satisfy i) and ii).

i) $\beta_{ijk1}=\beta_{jk1}<1$ and $e_{ijk1}=e_j*(1)$ for every worker i in group k, j=1,2, and j=k.

ii) $\alpha_{ijk1}=\alpha_{jk1}$ and $y_{ijk1}^M=y_{jk1}^M$ for every worker i in group k, j=1,2, and j=k, where $\alpha_{jk1}+\beta_{jk1}[c_j+d_j(E(\theta^k)+e_j*(1))-z-y_{jk1}^M]>c_j+d_j(E(\theta^k)+e_j*(1))-z$.

Part i) states that effort choices in period 1 are efficient just like in period 2. The difference is that, as also captured in i), firms do not set the bonus rate for a worker in group k such that the marginal increase in the bonus due to increased effort just equals the marginal increase in productivity due to increased effort. Rather, bonus rates are set so that the marginal increases in the bonus due to increased effort are below the marginal increases in productivity. The reason is that workers perceive an increased probability of subsequent promotion from an increase in effort (we elaborate on this point in the next section) and firms take this into account in setting period 1 bonus rates.

The other result captured in Lemma 2 concerns how salaries and minimum outputs are determined. As captured in Lemma 1, because of firm specific human capital and asymmetric learning, a firm earns positive expected period 2 profits from hiring a worker in period 1. Since competition in period 1 means firms earn zero expected profits over the two periods from hiring a worker in period 1 and bonus rates are chosen in the manner that achieves efficient effort choices, it is the choice of salaries and minimum output levels that achieves this zero profit condition. The end result, as captured in the lemma, is that expected compensation for each worker in period 1 exceeds the worker's expected period 1 output.

IV. EQUILIBRIUM AND TESTABLE IMPLICATIONS

In this section we describe the full equilibrium of the model which follows from the preliminary results in the previous section. We then derive testable implications. As was true for the preliminary results in the previous section, throughout we impose a set of parameter restrictions that ensure that a group k worker is assigned to job k in period 1, a group k worker is assigned to either job level k or job level k+1 in period 2, and probabilities of promotion are strictly below efficient levels as is standard in promotion signaling models.

Let θ_k' be the critical value for innate ability for old workers in group k such that in period 2 it is efficient to assign old worker i in group k with previous experience at the current employer to job k+1 when $\theta_i>\theta_k'$ and to job k when $\theta_i<\theta_k'$. To be precise, θ_k' satisfies $s_2[c_k+d_k(\theta_k'+e_k^*(s_2))]-g(e_k^*(s_2))=s_1[c_{k+1}+d_{k+1}(\theta_k'+e_{k+1}^*(s_1))]-g(e_{k+1}^*(s_1))-z$. Also, we assume parameters are such that $\theta_1^L<\theta_1'<\theta_1^H<\theta_2'$ and $\theta_1'<\theta_2^L<\theta_2'<\theta_2^H$. That is, it is efficient in period 2 for a θ_k^L worker to be assigned to job level k by the first period employer and for a θ_k^H worker to be assigned to job level k+1.

Proposition 1 describes equilibrium behavior in our model. Also, below a promotion refers to a worker being assigned to a job level one level higher than the worker was assigned to in the previous period, while not being promoted means the worker is assigned to the same job level as in the previous period.

Proposition 1: There exist values θ_1^+ and θ_2^+, $\theta_1^+>\theta_1'$ and $\theta_2^+>\theta_2'$, such that equilibrium behavior is described by i) through iii).

i) In period 1 every worker in group k, k=1,2, is assigned to job k by the worker's period 1 employer and compensation contracts and effort choices satisfy i) and ii) of Lemma 2.

ii) In period 2 every worker i in group k, k=1,2, is promoted by the first period employer if $\theta_i \geq \theta_k^+$ and not promoted if $\theta_i < \theta_k^+$.[16]

iii) In period 2 every worker i in group k, k=1,2, stays with the first period employer and the compensation contracts and effort choices satisfy i), ii), and iii) of Lemma 1.

The proposition combines results from the previous section and also introduces the new result that, as is standard in promotion signaling models, there is a distortion in the promotion decision, i.e., $\theta_k^+ > \theta_k'$ for k=1,2. The logic for the distortion is the same as found in many earlier papers in the literature. When a worker is promoted at the beginning of period 2 by the worker's first period employer a positive signal is sent to prospective employers about the worker's ability. As a result, a promotion causes the compensation associated with moving to increase, which in turn means that in order to retain a promoted worker the first period employer must also make its compensation contract more attractive. Since making the compensation contract more attractive is costly to the first period employer, there is a promotion distortion in the sense that firms do not promote workers who are only slightly more productive on the higher level job.[17]

A further point to note is that, although in Proposition 1 promotions occur for each group of workers when innate ability is above some critical value, we could have instead written the proposition to state that a promotion occurs when the worker's output is above some critical

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[16] We assume a firm promotes a worker whenever the firm is indifferent between promoting and not promoting the worker. Note it is possible in this model that no one is promoted, i.e., $\theta_k^+ \geq \theta_k^H$ for all k, k=1,2. This is not unusual in promotion signaling models – see, for example, Waldman (1984a). The corollaries concern parameterizations in which there is a strictly positive probability of promotion for each worker group.

[17] An interesting aspect of this model is that in some of the parameterizations ruled out by our parameter restrictions there is either no promotion signaling distortion or the distortion is that the probabilities of promotion are too high rather than too low. This can arise if the efficient cutoff ability levels for promotion for a worker who leaves is sufficiently above the efficient cutoff ability level for promotion for a worker who stays which does not arise in the model given our parameter restrictions. See Golan (2005) and Waldman and Zax (Forthcoming) for analyses focused on the robustness of the promotion signaling distortion.

value. In this model first period employers observe first period outputs and correctly infer workers' innate ability levels. So saying that a worker's innate ability level is above some critical value and is promoted is equivalent to saying that the worker's output was above some critical value and this is what led to the promotion. And it is this relationship between first period output and second period promotion which causes the possibility of subsequent promotion to serve as an incentive for first period effort.

Overall, the main point of the proposition is that in this model incentives stem from two sources: current monetary payments for high output due to the bonus included in the compensation contract and in period 1 future monetary rewards due to the promotions that follow when a worker produces high output. Further, the bonus rate is always set so that a worker chooses the efficient level of effort.

We now turn to testable implications, where our focus is variation in the size of the bonus payment. We start with results concerning how bonus payments vary with job level.

Corollary 1: Holding job level tenure constant, the average bonus payment strictly increases with job level for old workers and also, if δ is sufficiently small, strictly increases with job level for young workers.

Corollary 1 says that the average size of bonus payments rises with job level holding job level tenure and worker age fixed. There are two main reasons for this. First, because the marginal increase in output with respect to effort rises with job level, workers at higher job levels choose higher effort levels which translate into higher bonuses. Second, the higher marginal increases in output at higher job levels directly translate into higher bonuses.

One question is what is the role of the condition that δ must be small for this result to hold unambiguously for young workers. The answer concerns the trade-off in our model between bonus incentives and promotion incentives. In our model for young workers bonus incentives are set to augment promotion incentives so that effort choices are efficient. It is possible that promotion incentives rise so much at higher levels of the job ladder that bonus incentives fall and, in particular, the average bonus falls. If δ is small, then the difference in promotion incentives between young workers assigned to levels 1 and 2 is second order.

The next result concerns the relationship between bonus size and job level tenure.

Corollary 2: For old workers on job level 2, holding all other parameters fixed, the average bonus payment increases with job level tenure.

The first thing to note about Corollary 2 is that it only refers to old workers on job level 2. The reason is that in our model this is the only group of workers for whom job level tenure in fact varies. For example, all young workers on either job level are in their first period at that level, while old workers on level 1 are all in their second period at that level. The basic logic behind the corollary is that task specific human capital increases productivity for workers with previous experience at that level and the higher productivity increases equilibrium effort which in turn increases the bonus payment.

In Corollary 3 we consider the relationship between bonus size and worker age.

Corollary 3: For workers on job level 2, holding job level tenure constant, the average bonus payment increases with worker age if s_1 is sufficiently large.

Corollary 3 refers only to workers on job level 2 because that is the only job level for which workers assigned to that level vary in terms of age after controlling for job level tenure. The corollary states that bonus payments for these workers increase with age if general human capital accumulation as workers age is sufficiently large.[18] There are two reasons that bonus payments in this model increase with age after controlling for job level and job level tenure.

[18] Since $s_1 > h_1$, one way to guarantee that s_1 is sufficiently large is to assume h_1 is large.

First, old workers choose higher effort levels because of general human capital accumulation. Second, old workers have no promotion incentives since this is their last period in the labor market, so achieving efficient effort incentives requires a higher bonus. But there is a third factor which is that for young workers the expected bonus includes the bonus rate multiplied by the average innate ability in a group minus the minimum innate ability in that group while old worker bonuses do not include such a component. The condition that s_1 is sufficiently large means this factor is dominated by the other two which, in turn, yields the prediction that bonus payments should rise with age.

We now consider how performance is related to the size of bonus payments.

Corollary 4: Holding job level fixed, bonus payments rise with output for young workers.

This prediction is not surprising. It simply says that bonus payments increase with performance which is true for young workers as long as the bonus rate is positive. Given our assumption that δ is sufficiently small that the bonus rate is always positive, we have that bonus payments increase with performance for young workers. For old workers there is no variability concerning the bonus payment for workers on a given job level because there is no stochastic term in the production functions. If we introduced a stochastic term, then there would also be a positive relationship between performance and the size of bonus payments for old workers.

Our last prediction concerns how changes in promotion based incentives affect bonus size. In order to explore this relationship we conduct a comparative statics analysis of how bonus size is affected by a change in δ. The basic logic is that as δ increases, i.e., there is less discounting, promotion incentives become more important in a worker's choice of effort in period 1.

Corollary 5 formally states what happens to bonus size for young workers when δ increases.

Corollary 5: An increase in δ, holding all other parameters fixed, results in a decrease in the average bonus payment for young workers on each job level.

The logic is again captured by the idea that in our model the bonus is always set equal to the value that achieves the efficient effort level. Increasing δ increases promotion incentives for young workers. But an increase in δ has no effect on the efficient effort levels for young workers. So when promotion incentives rise but there is no change in the efficient effort levels, the result is a decrease in the size of bonuses required to achieve efficient effort levels.

Note that the more general theoretical prediction here is that an increase (decrease) in the promotion prize results in lower (higher) bonus payments. In the corollary we model this as a change in the value of the promotion prize due to a change in discounting but any change which affected the value of the promotion prize but not the efficient effort level on the low level job would result in the same prediction. See Devaro and Waldman (2012) and Bognanno and Melero (Forthcoming) for analyses that show that in promotion signaling models there are various factors that affect the size of promotion prizes that are independent of the efficient effort levels at the low level jobs.

In summary, our model has five testable implications. First, bonus size should rise with job level holding job level tenure and worker age constant. Second, bonus size should rise with job level tenure holding both job level and age constant. Third, bonus size should rise with age holding job level and job level tenure constant. Fourth, bonus size should rise with performance holding job level and age fixed. Fifth, an increase in promotion incentives which we model as an increase in δ should cause bonus size to decrease. Note that one of the predictions depends on human capital accumulation being substantial but this is likely the case in the firm we focus on in our empirical analysis given the nature of age-earnings profiles in the firm's industry.

V. DATA

The data used in our empirical analysis comes from the personnel records of a medium-sized US firm operating in the financial services industry. This dataset was first analyzed in the seminal studies of Baker, Gibbs, and Holmstrom (1994a,b) that focused on various aspects of the internal labor market operations of this firm. The full dataset covers all the managerial employees at the firm over the period 1969-1988 and includes salary, bonus, and subjective performance variables, as well as demographic variables including age, race, gender, and years of education. For our purposes, the variables of special interest are job levels, bonuses, and performance ratings.

Since the HR department at the firm did not provide any information about job levels, Baker, Gibbs, and Holmstrom constructed job level data from the raw data by using typical movements between job titles. In their original study, Baker, Gibbs, and Holmstrom identified 8 levels, where level 8 is the top level filled by the CEO. Since the manner in which CEO compensation is determined is likely different than the way compensation is determined for other firm employees and since there are few employees at the top levels, we drop observations concerning level 8 and combine observations from levels 6 and 7 with those from level 5.[19] Subjective performance ratings are measured on a five-point scale, where 1 represents the best performance and 5 the worst. Note that performance ratings are not available for all observations in the dataset (69.8 percent of the sample we employ include a performance rating), so the sample is smaller when we include performance ratings in the regression specification.

Salaries and bonuses are reported annually and are measured in real terms in 1988 dollars. Bonuses are only reported for the time period 1981-1988, so that is the part of the sample we use (we do, however, use observations from earlier years to construct lagged values of some variables). Bonuses for a given year are paid in February of the following year, where not all eligible employees earn a bonus (about 24.5 percent of all worker-years in our sample

[19] We follow Gibbs (1995) in dealing with the data in this way.

include a strictly positive bonus). As we discuss in the next section, the testable predictions of our model concern the size of actual bonus payments rather than eligibility to earn a bonus or expected bonus payments. Therefore, our focus is worker-years in which a positive bonus is paid. But we first analyze the probability workers earn bonuses before turning to testable predictions.

In addition to restricting our sample to the time period in which bonus data is available, we also restrict our sample in two other ways. First, since compensation data are in local currencies, we only include observations of workers employed in US plants. Second, we drop observations in which the worker received a demotion (there are only 47 observations that include demotions in the time period we study).

These restrictions leave us with a sample consisting of 8,428 worker-years and 3,890 workers. Summary statistics are reported in Table 1. The average worker is 39.1 years old and the average value for tenure at the firm is 6.1 years. Focusing on job level, we see that as job level increases workers on average are older, have higher values for tenure, receive better performance ratings, and earn larger bonuses. It is also interesting to note that the bonus-salary ratio increases with job level, i.e., the proportion of total compensation which comes from the bonus is higher at higher levels of the job ladder.

VI. EMPIRICAL ANALYSIS

The empirical analysis consists of three parts. We start with a preliminary examination of the firm's bonus policy. In particular, we provide an analysis of which worker attributes are related to the probability a bonus is received. We then test predictions concerning the relationships between job level, job level tenure, age, performance, and bonus payments. In our final set of tests we focus on the prediction concerning the trade-off between bonus payments and incentives provided through promotions.

A) Some Preliminary Tests

In this subsection we focus on worker attributes correlated with the probability of receiving a bonus. In particular, we test the extent to which this probability is correlated with job level, job level tenure, performance, wage growth, average salary increase at the current level, and whether or not the worker was promoted. Our theory suggests that the probability a worker receives a bonus should be positively related to worker effort which itself should be correlated with variables such as job level, job level tenure, and performance. Identifying the correlations between these variables and probability of receiving a bonus provides evidence concerning whether our general theoretical approach to modeling bonuses is correct. In the next subsection we focus on the specific testable predictions derived in the theoretical analysis.[20]

We estimate logit specifications where the dependent variable is an indicator variable that takes on a value of one if the worker received a bonus in the given year and zero if not. Results are reported in Table 2. In columns 1 to 4 we do not include fixed effects while in columns 5 through 8 we add individual fixed effects. We start our discussion with columns 1 through 4. The explanatory variables in column 1 are indicator variables for job level and performance ratings (the omitted categories are level 1 and performance rating equal to 1). We find that the probability of a bonus payment increases with job level and performance (remember that a higher performance rating represents worse performance), where all coefficients are statistically significant at the one percent level and differences between coefficients are all statistically significant at the one percent level.

In columns 2 through 4 we add an indicator variable for whether the worker received a promotion in the following year, a variable capturing average salary increase at the current level, and indicator variables for tenure at the current level (where the omitted category is tenure equals 1, i.e., this is the worker's first year at the current level). Adding these additional explanatory

[20] We do not refer to any tests in this subsection as tests of the theory since taken literally our model predicts a bonus should basically always be paid. Although, if we assumed the bonus payment could not be negative and allowed promotion incentives to exceed efficient incentives, one could use a variant of our model to derive predictions concerning the probability of receiving a bonus.

variables does not change the qualitative nature of our findings concerning the correlations between job level, performance ratings, and the probability of receiving a bonus. Further, we find that promotion and average salary increase at the current job level are both positively correlated with the probability of receiving a bonus, while this probability first increases and then decreases with tenure at the current level (remember that the omitted category is the minimum value for this variable).

As indicated, in columns 5 through 8 we add individual fixed effects. The results are mostly qualitatively unchanged. But there are a few differences. First, the probability a bonus is paid is no longer monotonically increasing with the job level. Rather, it increases up to level 4 but the coefficient on the job level 5 variable is smaller than the job level 3 and 4 coefficients in each of columns 5 through 8. Second, the coefficient on average salary at the current level in column 7 is negative but not statistically significant which is qualitatively different than the positive and statistically significant coefficient found for this variable in column 3. Third, the probability of bonus pay now monotonically increases with job level tenure up to tenure equal to 4 but then is lower for the highest job level tenure category.

Overall, the results in Table 2 provide a number of interesting insights concerning the data. For example, the probability of a bonus payment rises with job level as found in a number of earlier studies and the finding remains after controlling for various factors such as performance ratings and job level tenure. So, for example, the job level result is not driven by the possibility that the probability of a positive bonus payment is positively correlated with performance and average performance rises with job level. Also, not surprisingly, the probability of a bonus rises with performance which is consistent with our theoretical approach (and many others) which predicts bonuses rise in response to a high level of performance.

There are also results suggestive of our theoretical prediction of a trade-off between bonus payments and incentives derived from the possibility of future promotion. The omitted category for job level tenure is job level tenure equal to 1 which, except for workers who just started at the firm, consists of workers who were just promoted into their current level. So if there is a trade-off between bonus incentives and promotion incentives, the probability of receiving a bonus should be smaller for this lowest job tenure group which is basically what we find. The coefficients on job level tenure equal to 2, 3, and 4 are all positive and in the fixed effects specification they are all statistically significant at the one percent level. This means the probability of receiving a bonus is smaller for the omitted category which is the group with job level tenure equal to 1. For job level tenure greater than or equal to 5 the coefficient is negative and statistically significant at the ten percent level in the absence of fixed effects, but with fixed effects this coefficient is positive although statistically insignificant.

A related finding concerns the indicator variable for promotion in the following year. One could imagine that, for many promotions, prior to the promotion the worker may have achieved a level of performance such that a promotion is warranted but promotion is delayed for a year or two (this does not arise in our model, but could arise if we added slot constraints). So, if bonus incentives and promotion incentives are substitutes, one might predict that bonus incentives would rise in periods in which performance has increased high enough to warrant a promotion but promotion is delayed. The findings in columns 2 through 4 and 6 through 8 are consistent with this prediction. That is, in each column the coefficient on the indicator variable for promotion in the following year is positive and statistically significant which is consistent with bonus incentives being higher when promotion is warranted but delayed.

B) Job Level, Job Level Tenure, Age, and Bonus Payments

We now turn to the testable predictions derived in the theory section. In this subsection we focus on the first four testable predictions which concern how bonus payments vary with job level, job level tenure, age, and performance. In the next subsection we consider the fifth testable prediction which concerns the trade-off between bonus incentives and promotion incentives.

Before proceeding to the formal tests, it is useful to consider the basic data on bonuses categorized by job level. As seen in Table 1, the average bonus payment increases with job level, where the overall bonus structure is convex in the sense that the increase between adjacent levels is higher at higher levels. It is also the case that the bonus/salary ratio rises with job level and, as shown in Figure 1, the median bonus payment as well as bonus payments at the 25th and 75th percentiles of the distribution increase with job level. Our theory predicts that the positive relationship between bonus size and job level should hold even after controlling for job level tenure, worker age, and other control variables, while there should also be a positive relationship between bonus size and job level tenure after including controls and bonus size and age after including controls. This is what we consider next.

To empirically test these predictions we employ the following econometric specification.

(2) $$\log \beta_{it} = Z_i\varphi + X_{it}\tau + \alpha_{it}\gamma + \sum_{j=2}^{5} L_{it}^{j}\delta^{j} + t_i + \mu_i + \varepsilon_{it}$$

In equation (2) $\log \beta_{it}$ is the log of bonus payments made to worker i in year t; Z_i is a vector of time-invariant attributes of worker i which includes indicator variables for the worker's race, gender, and education level; X_{it} is a vector of time-varying attributes of worker i which includes tenure at the current job level and performance ratings at year t to capture variation both across workers and for a given worker over time in productivity; α_{it} is a vector that includes the age of worker i in year t and its squared term (divided by 100 for convenience); L_{it}^{j} is a level-specific binary indicator variable (j=2,3,4,5), where $L_{it}^{j}=1$ if $L_{it}=j$ and 0 otherwise and L_{it} is the job level of worker i in year t;[21] t_i is a vector of year indicator variables used to control for the effect of the business cycle on bonus payments; μ_i is a worker-specific unobserved factor that may be correlated with other explanatory variables;[22] and ε_{it} is an idiosyncratic error term that is independently and identically distributed with mean zero.

A crucial point in testing for the effect of job level on bonus payments is the assignment of workers to job levels. As our theoretical model illustrates, more able workers are assigned to higher job levels in equilibrium. Even though proxies for performance and ability are included

[21] Level 1 is the omitted category.

[22] We do not employ a random-effects estimation in the empirical analysis since its restriction that the worker-specific unobserved factor must be uncorrelated with the explanatory variables is not realistic in the current model.

in the regressions, a part of the variation that affects job assignment is likely not captured by these variables. As a result, indicator variables for job levels may be correlated with the disturbance term and their point estimates may consequently be biased. With this in mind, we begin the analysis with the ordinary least squares (OLS) estimation on pooled data. Since OLS estimation requires the most rigid conditions to produce unbiased estimates, results from the pooled regressions are used as a benchmark. Then, in order to mitigate the effect of unobserved worker heterogeneity, we make use of the panel dimension of the data by employing a fixed effects estimation which relaxes conditions required by the OLS estimation.[23,24]

We first examine how much of the variation in the size of the bonus payments is explained by the variation in job levels, job level tenure, and age terms. With this in mind, we estimate simple regressions in which job level indicators, indicators for tenure at level, and age terms are the only independent variables. Results are reported in Table 3. Consistent with previous studies such as Leonard (1990) and Ortin-Angel and Salas-Fumas (2002), job levels are an important determinant of bonus size. As seen in column 1, in our sample 52.1 percent of the cross sectional variation in bonus size is explained by job levels, while column 2 tells us that 6.2 percent of the cross-sectional variation in bonus size is explained by age and column 4 says that 9.7 percent of the cross-sectional variation is explained by tenure at level. In column 3 we include job level indicator variables and age terms, while in column 5 we add to the column 3 specification the indicator variables for job level tenure. In both of these columns we see that the adjusted R^2 is not much higher than when job level indicators alone were included in column 1. The conclusion is that in the cross section variation in bonus payments is largely explained by job levels, while job level tenure and age have minor explanatory power.

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[23] In our theoretical model, many of our predictions hold both for a given worker and on average. But changes in the model such as having output be a function of ability times effort rather than ability plus effort would result in worker ability and bonus size being correlated. Given this, considering regressions with and without fixed effects seems like the best approach.

[24] Technically, the OLS estimation yields unbiased estimates if ability differences that affect worker assignments to job levels are fully accounted for by the variables used in the specification, i.e., $E[L_{it}^j \cdot \eta_{it} \mid Z_i, X_{it}, \alpha_{it}, t_i]=0$ for all t and j, where $\eta_{it}=\mu_i+\varepsilon_{it}$. The fixed effects estimation, on the other hand, relaxes this condition by assuming that the unobserved attributes of workers that affect their job assignment are fully captured by the time-invariant individual-specific factor, i.e., it requires that $E[L_{it}^j \cdot \varepsilon_{it} \mid Z_i, X_{it}, \alpha_{it}, \mu_i]=0$ for all t and j

Table 4 reproduces the Table 3 tests but adds fixed effects. These tests indicate how much of the within worker variation over time in bonus payments is explained by variation over time in job levels, job level tenure, and age. Columns 1, 2, and 4 tell us that each of job levels, job level tenure, and age explain around 80 percent of the within worker over time variation in bonus payments. Similar to what was true for the cross-section, when we include both job level and age terms in column 3 and job level, job level tenure, and age terms in column 5 the explanatory power of the model increases very little.

Table 5 shows the results of estimating equation (2) for alternative specifications. Columns 1 through 4 show the OLS pooled regression results while 5 through 8 show the fixed effects regression results.[25] Controls for gender, race, education level, and year indicator variables are included in each of the pooled regressions, while they are dropped in the fixed effects regressions. Recall that the first prediction of our theoretical model is that, holding job level tenure and age constant, bonus payments increase with job level, i.e., $\delta^{j+1}>\delta^{j}>0$ for j=1,2,3, and 4.

The results reported in Table 5 provide clear support for our first theoretical prediction. In each regression the coefficients on the job level indicator variables increase with the job level and in seven of the eight regressions the coefficients are all statistically significant at the one percent level (in column 6 which is the fixed effects regression that includes performance ratings three of the four coefficients are statistically significant at the five percent level while the remaining coefficient is not statistically significant at standard significance levels).[26] The results also suggest that unobserved worker heterogeneity plays an important role in workers' assignments to job levels. This follows since the coefficients on the job level indicator variables fall sharply, especially at higher job levels, when we include worker fixed effects. However, as

[25] As mentioned earlier, performance ratings are not available for all worker-years of data. As a result, the number of observations decreases from 8,428 to 5,851 in specifications that include performance ratings. We have estimated the specifications investigated in columns 1, 3, 5, and 7 employing the subsample for which performance ratings are available and the results are qualitatively unchanged.

[26] Differences between coefficients for adjacent job levels are also in many cases statistically significant at a significance level of at least five percent. Also, note that columns 3 and 7 are the closest match to Corollary 1 because job level tenure and age, but not performance, are controlled for.

already indicated, the results support the first theoretical prediction even when worker fixed effects are included in columns 5 through 8.

Our second testable prediction is that bonus size should vary positively with job level tenure holding job level and age fixed. Table 5 also provides support for this prediction. In columns 3 and 7 where performance ratings are not included the coefficients on the job level tenure variables are all positive as predicted and statistically significant at the one percent level. Further, the size of the coefficient rises with tenure and many of the differences are statistically significant at the five percent level. In column 4 which includes performance ratings but not individual fixed effects the results are qualitatively the same. In column 8 which includes performance ratings and individual fixed effects the coefficients for the job level tenure variables equal to 2, 3, and 4 are all positive and statistically significant at least at the five percent level. However, the coefficient on the variable job level tenure greater than or equal to 5, although positive, is not statistically significant. Also, the column 8 results do not exhibit the monotonic increase in the size of the coefficient as job level tenure increases found in columns 3, 4, and 7.[27]

We now turn to our third prediction which is that bonus payments should increase with worker age after controlling for job level and job level tenure. Since in our specification we include both age and age squared as explanatory variables and the dependent variable is the log of the bonus payment, the effect of age on bonus payments is measured by the semi-elasticity of bonus payments with respect to age. From equation (2) we can derive that this elasticity term is given by $\gamma_1+y(1/50)\gamma_2$, where y is the age level at which the elasticity is evaluated. The bottom panel of Table 5 shows the F-statistic and the associated p-value for the null hypothesis that the semi-elasticity of bonus payments with respect to age is zero for the average worker. Clearly, age matters.

In the regressions without fixed effects we find support for the idea that older workers earn larger bonuses, on average, in columns 1 and 2, while all four fixed effects regressions show

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[27] Note that columns 3 and 7 are the closest match to Corollary 2 because job level and age, but not performance, are controlled for.

this result.[28] Because the fixed effects regressions control for unobserved worker heterogeneity, we focus on columns 5 through 8 in the following discussion. In each regression the coefficient on the age variable is positive and statistically significant at the one percent level, while the coefficient on the age squared variable is negative and statistically significant at the one percent level. Also, each coefficient is somewhat smaller in absolute value in columns 7 and 8 where tenure at the job level is included as an explanatory variable.

Figure 2 plots the age semi-elasticity of bonus payments using the point estimates from the fixed effects regressions. The figure shows that bonus size increases with age but eventually the relationship turns negative, where the critical age above which the age semi-elasticity turns negative is in the mid 40s for each of the regressions. Also, the results indicate that the effect of age on bonus size is economically significant at younger ages. For example, the column 5 results indicate that an additional year starting at age 40 leads to a 4.9 percent increase in the size of bonus payments, while in column 6 the analogous figure is 3.3 percent.

At first one might think that our theoretical approach is inconsistent with the size of bonus payments falling with age at high ages. But we believe, in fact, that this result is consistent with our theoretical approach. Our theoretical approach predicts that bonus size should continue to increase with age as long as higher ages are associated with substantial increases in general human capital. If, however, at high enough ages general human capital increases slowly or decreases with further increases in age, then the predicted relationship between age and bonus size becomes ambiguous.

The reason this point is relevant is that studies of age-earnings profiles and experience-earning profiles suggest that general human capital peaks at some point and, in fact, decreases with age at high ages. For example, using a quadratic specification, Murphy and Welch (1990) found that for workers with a high school education or higher (which is the case for a large proportion of our sample) the experience-earnings profile peaks at around twenty five years of

[28] Note that columns 3 and 7 are the closest match to Corollary 3 because job level and job level tenure, but not performance, are controlled for.

labor market experience. If we interpret this to mean that general human capital also peaks at approximately that level of labor market experience, then our theoretical approach would seem to be consistent with the results concerning age found in Table 5.[29]

The last theoretical prediction we consider in this subsection is that bonus size should increase with performance even after controlling for age, job level, and job level tenure (as indicated earlier, various other models of bonus payments would also make this prediction). The OLS results in columns 2 and 4 of Table 5 are mixed in that the relationship between bonus size and the performance ratings is not strictly decreasing as the theory predicts (remember, a higher performance rating means worse performance). But the fixed effects regressions reported in columns 6 and 8 show the predicted pattern. The coefficients fall monotonically as the performance rating rises and four of the six relevant coefficients are statistically significant at the one percent level.

C) Trade-Off Between Bonus Payments and Promotion Incentives

The fifth prediction is that there is a trade-off between incentives provided through bonus payments and incentives provided through the possibility of future promotion. Recall that since a worker experiences an increase in expected utility upon being promoted, the probability of being promoted provides a worker with an incentive to exert effort. If the promotion prize is larger which we capture in our theoretical modeling by decreasing discounting, then a smaller bonus rate is required to induce an efficient effort level.

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[29] Another possible explanation for our age results concerns the fact that in our firm managerial stock holdings and stock options are a third avenue that the firm employs to provide incentives. If, on average, at sufficiently high ages increases in incentives achieved through stock ownership and stock options as managers age exceed the increases in non-promotion incentives needed to maintain efficient effort as workers age, then our approach predicts that the size of bonuses should actually fall with age for high enough ages as we find in our empirical analysis.

Note that a number of studies have looked at stock holdings and the granting of stock options for CEOs and how both vary with CEO age. The evidence is mixed. For example, Lewellen et al. (1987) finds that the granting of stock options increases with CEO age while Eaton and Rosen (1983) do not. Also, Chug and Pruitt (1996) consider CEO stock ownership and finds that it does not rise with age after controlling for number of years as CEO. But we suspect that at lower job levels age may matter, especially for stock holdings, because overall wealth is likely to be highly correlated with age at lower managerial levels.

To test the prediction that the size of bonus payments is negatively related to the expected promotion prize, we first need to translate the prediction into a specific statement concerning what we observe in the data. The obvious candidate for measuring expected worker utility is expected total compensation, where total compensation refers to the sum of salary plus any bonus payment. However, for a worker who is not promoted in a given year we do not observe what compensation would have been if a promotion had taken place.

Let Δ_{it}^{e} be worker i's expected promotion wage increase in period t, where Δ_{it}^{e} is defined by equations (3) and (4). Note, in (3) and (4) below $prom_{it}=1$ means worker i is promoted in period t and $prom_{it}=0$ means the worker is not promoted.

(3) $$\Delta_{it}^{e} = \log C_{it+1}^{P} - \log C_{it} \text{ if } prom_{it}=1$$

(4) $$\Delta_{it}^{e} = \log C_{it+1}^{P,e} - \log C_{it} \text{ if } prom_{it}=0$$

In equations (3) and (4) $\log C_{it+1}^{P}$ and $\log C_{it}$ denote worker i's log compensation in period t+1 when the worker is promoted at the end of period t and worker i's log compensation in period t, respectively. For workers not promoted $\log C_{it+1}^{P}$ is not observed and must be predicted. The variable $C_{it+1}^{P,e}$ is the predicted value for C_{it+1}^{P} for workers not promoted.

We employ an approach similar to one employed in DeVaro and Waldman (2012) in analyzing a related problem to construct expected promotion wage increases. In particular, we take into account worker heterogeneity by employing a detailed set of control variables in constructing expected promotion prizes. In the first step we estimate equation (5) for the subsample of observations in which promotion occurred, where Y_{it}^{P} is a vector of control variables.

(5) $$\log C_{it+1}^{P} - \log C_{it} = Y_{it}^{P}\kappa_{Y} + \psi_{it}$$

For each non-promotion observation, we then construct an expected promotion wage increase by employing the values for the control variables for the observation and the estimated coefficients from our estimation of equation (5).

We use three different sets of control variables in estimating equation (5). The first set of control variables consists of worker age, job level, tenure at current level, performance rating, and worker fixed effects. Using these control variables we construct what we call Promotion Wage Increase A for each observation. For the second set of control variables we add to the prior list tenure at the firm, gender, and education level (worker fixed effects are removed) and we call the result Promotion Wage Increase B. Finally, for our third set of control variables we add to the second set just described job titles. The resulting predicted promotion prizes are called Promotion Wage Increase C.

One drawback of this approach concerns the endogeneity involving who earns promotions. Similar to the union membership problem, if earning a promotion is an endogenous choice which it surely is, the predicted compensation values may be biased. However, an important difference between earning a promotion and becoming a union member is that the selection criteria concerning who earns promotions is better understood than a worker's decision concerning whether or not to become a union member. Specifically, there is extensive evidence that an important determinant of promotion decisions is performance and we have detailed evidence concerning performance – there is no similar variable for union membership decisions. So, employing control variables for worker performance, indicator variables for job titles, and worker fixed-effects should address the endogeneity problem to a considerable extent.[30]

To incorporate the effect of promotions, let I_{it}^* denote a latent index variable such that worker i is promoted, i.e., $prom_{it}=1$, if and only if $I_{it}^* \geq 0$. We estimate a logit regression of the following form.

(6) $$I_{it}^* = \tau_1 X_{it} + \upsilon_{it},$$

[30] The two standard approaches for the estimation of endogenous treatment effects are instrumental variables and control function procedures (see Robinson (1989) for a discussion and references concerning this issue in the union membership context). To apply these techniques to our problem, however, would require a variable that is correlated with the probability of earning a promotion but is uncorrelated with the size of compensation changes. Since the probability of earning a promotion and the size of compensation changes are both determined to a great extent by worker performance, finding a variable with the required properties is a difficult task. One variable that would satisfy the required conditions is the separation decision of a worker in a higher managerial position. That is, such a separation can increase the probability of promotion for lower level workers who can potentially fill the now open position, but is likely uncorrelated with compensation increases for any promoted worker and also those not promoted. Unfortunately, this information is not available in our dataset.

where X_{it} is a vector of control variables and it includes the worker's gender, job level, tenure at the current job level, age, indicator variables for education categories, and the worker's relative performance rating (defined as the ratio of the worker's rating to the average rating among workers at the same job level).[31] Using parameter estimates from (6), we then derive an expected promotion probability for each observation, $prom_{it}^{e}$.

Finally, using the expected promotion probability for each observation and the three estimates for promotion wage increases, we construct three estimates for expected promotion prizes which we denote Promotion Prize A, Promotion Prize B, and Promotion Prize C. Specifically, this construction is given in equation (7).

$$(7) \qquad \Psi_{it}^{e} = prom_{it}^{e} \times \Delta_{it}^{e}$$

Using the three estimated promotion prizes, we estimate equation (8) which is an augmented version of equation (2) and report the results in Table 6.

$$(8) \qquad \log \beta_{it} = \Psi_{it}^{e}\rho + Z_i\varphi + X_{it}\tau + \alpha_{it}\gamma + \sum_{j=2}^{5} L_{it}^{j}\delta^{j} + \varepsilon_{it}$$

Since equation (8) includes a predicted variable, Ψ_{it}^{e}, as an independent variable, conventional methods underestimate standard errors (see Murphy and Topel (1985) for a discussion). Therefore, we have to adjust standard errors to take into account the sampling variability of this term. In particular, we implement a non-parametric bootstrap method which allows us to use the variation in the bootstrapped estimates of ρ to adjust the standard error estimated from the original sample.[32]

The top panel of Table 6 reports results when we employ Promotion Prize A, while the middle panel reports results for Promotion Prize B and the bottom panel shows results for Promotion Prize C. In the first column of each panel we include no controls that are in addition

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31 We obtain similar results when we use indicator variables for absolute performance ratings rather than relative performance ratings.

32 The method we implement is very similar to the approach that is used to compute standard errors with multiple imputed data (see Rubin (1987)). It can be summarized as follows. Drawing independent random samples from the subsamples of promoted and non-promoted workers, respectively, we first generate 50 datasets in addition to the original one. Then, we estimate (7) for each bootstrap sample and save the results. The corrected standard error is given by the formula $(s_P^2+\sigma_P^2)^{1/2}$, where s_P^2 is the sample variance estimated from the original sample and σ_P^2 is the variance of the point estimates across the bootstrap samples.

to the Promotion Prize variable except for the standard controls that consist of age, race, gender, education level, job level, and year. In the second column we add performance ratings as explanatory variables, while in the third column we add tenure at the current job level but do not control for performance ratings and in the fourth column we add average salary increase at the current job level but do not control for performance ratings or job level tenure. In the final column we include as controls performance ratings, tenure at the current job level, and average salary increase at the current job level. We consistently find that, as predicted by our theoretical model, the coefficient on the promotion prize variable is negative and statistically significant at the one percent level.[33]

To get a sense of the magnitude of the effect, consider the top panel which reports results for Promotion Prize A (the results for the other promotion prizes reported in the lower panels are similar). In the first column which does not include any additional controls, the coefficient on the promotion prize variable is -2.283 which means that a ten percent increase in the expected promotion prize leads to a 2.3 percent decrease in bonus payments. In columns 2 through 5 we include additional controls and the result is that the coefficient rises or falls somewhat in absolute value, where the largest effect is in column 2 in which only performance ratings are added.

VII. CONCLUSION

One way in which firms frequently provide workers with an incentive for effort is through the use of bonus contracts. In this paper we have focused both theoretically and empirically on understanding the determinants of the size of bonuses and, in particular, our focus has been on thinking about bonuses in a setting characterized by promotion tournaments as first analyzed by Lazear and Rosen in their seminal 1981 paper. In previous literature focused on promotion tournaments no distinction is typically made between salary based compensation and

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[33] The regressions reported in Table 6 do not include worker fixed effects. We continue to find results consistent with the theoretical prediction, however, when worker fixed effects are included.

bonus based compensation. We extend the tournament literature to capture this distinction and then empirically investigate the resulting testable implications.

In constructing a tournament model which makes a distinction between salary and bonus payments we employ a hybrid approach that combines elements of the classic tournament approach found in Lazear and Rosen's (1981) paper and the market-based approach first explored in Gibbs (1995) and Zabojnik and Bernhardt (2001). In our model at the beginning of each period the firm commits to a compensation contract consisting of a salary, minimum output level required to achieve a bonus, and a bonus rate. This is like the classic approach in the sense that the firm has some commitment ability in determining compensation. But the compensation increase that follows a promotion is due to the signaling role of promotion which is the approach taken in the market-based approach.

Our theoretical analysis yields five predictions. First, bonus size should increase with job level holding job level tenure and worker age fixed, where the logic of this prediction is that the return to worker effort increases with job level in our model so the efficient effort level increases with job level. Second, bonus size should increase with job level tenure holding job level and age fixed. This follows given our assumption of task specific human capital. Third, holding job level and job level tenure fixed, bonus size should increase with worker age. One reason is that higher age means more human capital accumulation and this increases the efficient effort level. Fourth, bonus size should increase with performance holding fixed job level, job level tenure, and age. Fifth, bonus size is negatively related to the size of expected promotion prizes. Here the argument is that in aggregate bonus incentives plus promotion incentives in equilibrium achieve efficient effort levels. So if expected promotion prizes are larger, then smaller bonuses are needed to achieve efficient levels.

After developing these five predictions, we provide an empirical analysis using the dataset first employed in Baker, Gibbs, and Holmstrom's (1994a,b) classic empirical study of wage and promotion dynamics in the financial services industry. Our empirical analysis supports all five predictions, although the prediction concerning age only holds for workers up to approximately age 45. As we discussed in detail earlier, we feel this result is in fact consistent with our theoretical approach given existing empirical evidence which suggests that general human capital typically peaks when workers are in their mid 40s.

There are a number of directions in which the analysis presented here could be extended. For example, we think it would be interesting to formally extend both the theoretical and empirical analyses by incorporating stock ownership and stock options. Many firms provide incentives at higher job levels through stock ownership and stock options. There should thus be a trade-off between incentives provided through stock ownership and stock options and bonus size similar to the trade-off focused on in this paper between bonus size and promotion incentives. We think it would be of interest to add this third avenue through which incentives can be provided into a promotion tournament type setting and formally investigate both theoretically and empirically the predictions that result.

Another direction of interest would be to employ a multiple firm dataset rather than the single firm dataset investigated here. This would allow us to both investigate the extent to which our theoretical predictions hold across a range of firms and also investigate whether or not the validity of our predictions depends on observable firm attributes. And we also made a number of simplifying assumptions to keep the theoretical model tractable and it might be fruitful to relax some of these assumptions to the extent possible. This includes extending the analysis to more periods and allowing for worker risk aversion.

APPENDIX

In the Appendix we provide proofs of the lemmas, propositions, and corollaries in Section II. In the proof of Proposition 1 we also provide the parameter restrictions that guarantee the conditions described at the beginning of Subsection III.B. Note also that due to space considerations proofs are somewhat abbreviated.

Proof of Lemma 1: In the proof of Proposition 1 we show that for each group k, k=1,2, there is a cutoff ability level θ_k^+, $\theta_k^+>\theta'$, such that worker i in group k is assigned to job 2 in period 2 by the first period employer if $\theta_i \geq \theta_k^+$ and is assigned to job 1 if $\theta_i < \theta_k^+$. For the proof of Lemma 1 we take this result as given.

Consider group k and the compensation determination process at the beginning of period 2. Given our trembling hand type assumption, the market contract offer will be consistent with zero profits under the assumption that a worker who moves is the lowest ability type among workers with the same labor market signal or job assignment, i.e., θ_k^L for workers not promoted and θ_k^+ for promoted workers. The logic is that this is the worker for whom the initial employer's foregone profits from making the mistake of not matching is the lowest. Further, this worker would be assigned to the same job the initial employer assigned the worker to if the worker were to move given $\theta_k^+>\theta_k'$ (this follows given a parameter restriction as discussed in the proof of Proposition 1). And also, competition among firms means the market contract offer will be the one that maximizes the utility of such a worker given the zero expected profit constraint. Given everyone is risk neutral, this yields that for workers initially assigned to job k the market offers a salary equal to $h_2(c_k+d_k\theta_k^L)$-z, the minimum output specified in the contract is the same value, and the bonus rate equals one, while for workers initially assigned to job k+1 the market offers a salary equal to $h_1(c_{k+1}+d_{k+1}\theta_k^+)$-z, the minimum output specified in the contract is the same value, and the bonus rate equals one.

Given the presence of firm specific human capital, i.e., $s_1>h_1$ and $s_2>h_2$, the initial employer always matches which means the utility of any worker assigned to job j from staying just equals the utility associated with the worker leaving. This is the second condition in iii) of the lemma given that efforts are chosen efficiently. The first condition in iii) follows from our assumption that the lower bound on the bonus equals zero (see footnote 14).

Finally, the initial employer will want to maximize second period profits in choosing the compensation contract for each worker given that the worker's utility associated with the contract just matches the worker's utility from accepting the market wage offer. As in any standard agency problem with risk neutrality this means the bonus rate is set equal to one and the worker chooses the efficient effort level. This proves i), ii), and iii).

Proof of Lemma 2: Given our focus is pure strategy Perfect Bayesian equilibria and given there is no stochastic element in the production functions, at the end of period 1 upon observing a worker's first period output a worker's first period employer and also the worker learn the worker's innate ability level with certainty. Also, at the beginning of period 2 other firms know this. It can also be shown that any specific belief about a worker's innate ability at the end of period 1 translates into unique behavior in period 2 which in combination with the previous results means that the specific contracts signed in period 1 have no effect on period 2 behavior.

We know from iii) of Lemma 1 and that there is firm specific human capital that hiring a worker in period 1 is associated with strictly positive expected profits in period 2. Competition among employers in hiring in period 1 thus yields that for workers in each group k expected compensation must exceed expected first period output. This proves ii) given a single contract is offered to workers in each group k in period 1 (and given $e_{ijk1}=e_j^*(1)$ which is proven below).

If $\theta_i \geq \theta_k'$, then given the market contracts derived in the proof of Lemma 1 it must be the case that $U^{2M}(\theta_{ik+1k2})>U^{2M}(\theta_{ikk2})$ (this is shown formally in the proof of Proposition 1). Given $\theta_k^+>\theta_k'$ for all k, k=1,2, we now have that $U^{2M}(\theta_{ik+1k2})>U^{2M}(\theta_{ikk2})$ if $\theta_i=\theta_k^+$.

Now consider the first period choice of effort of worker i in group k. This worker chooses first period effort to maximize the worker's expected discounted utility over the two periods which yields the first order condition $\beta_{kk1}d_k+\delta(\partial EU_{i2}(e_{i1})/\partial e_{i1})=g'(e_{i1})$, where $EU_{i2}(e_{i1})$ is the worker's expected utility in period 2 as a function of the first period effort choice. Let e_{1k}^* be the equilibrium effort choice in period 1 for workers in group k. In equilibrium this condition reduces to $\beta_{kk1}d_k+\delta(\partial EU_{i2}(e_{1k}^*)/\partial e_{i1})=g'(e_{1k}^*)$. We know that increasing first period effort increases the first period employer's belief concerning the worker's innate ability. Given the market contracts and iii) of Lemma 1, this only changes second period utility if the initial job assignment changes, i.e., second period utility is only affected if the increase in effort causes the initial employer's belief concerning the worker's ability to go from below θ_k^+ to be equal to or above θ_k^+. Further, since in equilibrium this belief is correct, $\theta_k^+ > \theta_k'$, and the market contract offers, we have that second period utility rises when an increase in effort causes the job assignment to change. This means $\partial EU_{i2}(e_{1k}^*)/\partial e_i > 0$ which, in turn, yields $\beta_{kk1} d_k < g'(e_{1k}^*)$.

By definition, we know $d_k = g'(e_k^*(1))$. Given this, now consider the equilibrium contract in period 1 for group k and the resulting choice of a first period effort level. The contract must maximize a group k worker's expected utility over the two periods subject to a zero expected profit constraint. But we know that the choice of a contract has no effect on second period expected utility so the contract must maximize first period expected utility subject to a zero expected profit constraint. Suppose $e_{1k}^* \neq e_k^*(1)$. Then there would be an alternative contract that results in the worker choosing $e_k^*(1)$, that satisfies zero expected profits, and that achieves higher expected worker utility which contradicts $e_{1k}^* \neq e_k^*(1)$. So $e_{1k}^* = e_k^*(1)$. But given $\beta_{kk1} d_k < g'(e_{1k}^*)$ and $d_k = g'(e_k^*(1))$ we have $\beta_{kk1} < 1$ for all k, k=1,2. This proves i).

<u>Proof of Proposition 1</u>: Later in the proof we provide the parameter restrictions that guarantee that group 1 workers are assigned to job 1 in period 1 and in period 2 are assigned to either job 1 or job 2, group 2 workers are assigned to job 2 in period 1 and either job 2 or job 3 in period 2, and there exist values θ_1^+ and θ_2^+, $\theta_1^+ > \theta_1'$ and $\theta_2^+ > \theta_2'$, such that in period 2 a worker in group k, k=1,2, with innate ability $\theta_i \geq \theta_k^+$ is assigned to job k+1 while a worker with innate ability $\theta_i < \theta_k^+$ is assigned to job k. Taking these conditions as given, iii) follows from the arguments in the proof of Lemma 1.

The next step is to provide the parameter restrictions that guarantee that group k workers, k=1,2, are assigned to job k in period 1. As stated earlier, given our focus is pure strategy Perfect Bayesian equilibria and given there is no stochastic element in the production functions, at the end of period 1 upon observing a worker's first period output a worker's first period employer learns the worker's innate ability level with certainty. Also, at the beginning of period 2 other firms know this and it can also be shown that any specific belief about a worker's innate ability results in a unique set of behaviors in period 2. Combining this result with the idea that competition for workers in period 1 means that period 1 equilibrium contracts and job assignments maximize expected worker utility subject to a zero expected profit constraint yields that the period 1 job assignment must maximize expected period 1 surplus. So workers in group 1 are assigned to job 1 in period 1 as long as $c_1+d_1(E(\theta^1)+e_1*(1))-g(e_1*(1))>\max\{c_2+d_2(E(\theta^1)+e_2*(1))-g(e_2*(1)),c_3+d_3(E(\theta^1)+e_3*(1))-g(e_3*(1))$. Similarly, workers in group 2 are assigned to job 2 in period 1 as long as $c_2+d_2(E(\theta^2)+e_2*(1))-g(e_2*(1))>\max\{c_1+d_1(E(\theta^2)+e_1*(1))-g(e_1*(1)),c_3+d_3(E(\theta^2)+e_3*(1))-g(e_3*(1))$. In turn, with these parameter restrictions i) follows from arguments in the proof of Lemma 2.

We now compare efficient assignment rules in period 2 for the period 1 employer and for prospective employers. As indicated earlier, for the first period employer the efficient assignment rule for period 2 for a worker in group k is to promote the worker when $\theta_i \geq \theta_k'$ and not promote the worker when $\theta_i < \theta_k'$, where θ_k' satisfies $s_2[c_k+d_k(\theta_k'+e_k*(s_2))]-g(e_k*(s_2))=s_1[c_k+d_{k+1}(\theta_k'+e_{k+1}*(s_1))]-g(e_{k+1}*(s_1))-z$. This follows given our assumption that $s_1d_{k+1}>s_2d_k$ for all k, k=1,2. For a prospective employer the efficient assignment rule is to assign the worker to job k+1 when $\theta_i \geq \theta_k^{M\prime}$ and to job k when $\theta_i < \theta_k^{M\prime}$, where $\theta_k^{M\prime}$ satisfies $h_2[c_k+d_k(\theta_k^{M\prime}+e_k*(h_2))]-g(e_k*(h_2))=h_1[c_k+d_{k+1}(\theta_k^{M\prime}+e_{k+1}*(h_1))]-g(e_{k+1}*(h_1))$. This follows given our assumption that $h_1d_{k+1}>h_2d_k$. Note that θ_k' increases with z while $\theta_k^{M\prime}$ does not and we assume that z is sufficiently large that $\theta_k'>\theta_k^{M\prime}$ which is a sufficient condition for the model to exhibit a promotion signaling distortion, i.e., the proportions of workers promoted by the first period employer are below the efficient levels.

The next step is to show that there exist values θ_1^+ and θ_2^+ such that $\theta_1^+>\theta_1'$ and $\theta_2^+>\theta_2'$ and ii) holds. In this step of the proof we assume no demotions and no promotions of more than one level. Call θ_{jk}^L the lowest ability worker in group k assigned to job j by the first period employer in period 2. Consider for the moment group 1 in which case our focus is θ_{11}^L and θ_{21}^L. Suppose they are both below $\theta_1^{M\prime}$. Then the market contract offers are such that a worker who moves receives the same utility whether the worker was assigned to job 1 or job 2 by the first period employer, so the market utility that must be matched is independent of the initial job assignment. But this means workers will be assigned efficiently in which case $\theta_1^{+}=\theta_1'$ which contradicts the supposition.

Suppose $\theta_{11}^{L}\geq\theta_1^{M\prime}$ and $\theta_{21}^{L}<\theta_1^{M\prime}$. Then the market contract offered to workers assigned to job 1 by the first period employer is consistent with the worker being assigned to job 2 by an alternative employer while the market contract offered to workers assigned to job 2 by the first period employer is consistent with the worker being assigned to job 1 by an alternative employer. We also know $\theta_{21}^{L}=\theta_1^{L}$ and $\theta_{21}^{L}<\theta_{11}^{L}$ in this case. But given our assumptions $s_1d_2-s_2d_1>h_1d_2-h_2d_1$ and γ small (see footnote 12), if the firm finds it profitable to assign a θ_1^{L} worker to job 2 then it must also find it profitable to assign a θ_{11}^{L} worker to job 2 which is a contradiction.

The only other possibility is that $\theta_{11}^{L}<\theta_1^{M\prime}$ and $\theta_{21}^{L}\geq\theta_1^{M\prime}$. Suppose $\theta_{21}^{L}=\theta_1^{M\prime}$. Then the market contract offers are such that if a $\theta_1^{M\prime}$ worker moves the worker receives the same utility whether the worker was assigned to job 1 or job 2 by the first period employer. But this means the first period employer should assign the worker to job 1 which is a contradiction. So we have $\theta_{11}^{L}<\theta_1^{M\prime}$ and $\theta_{21}^{L}>\theta_1^{M\prime}$. But this means that if a θ_{21}^{L} worker moves the worker receives higher utility when the worker was assigned to job 2 rather than job 1 by the first period employer. And this, in turn, means that $\theta_{21}^{L}>\theta_1'$ since otherwise the firm would have an incentive to assign the worker to job 1. Finally, given our assumptions $s_1d_2-s_2d_1>h_1d_2-h_2d_1$ and γ small, if the firm has an incentive to assign a θ_{21}^{L} worker to job 2 then it also has an incentive to assign any group 1 worker with higher innate ability to job 2. Thus, there exists a value θ_1^{+} with the specified properties. A similar argument yields that there is also a value θ_2^{+} with the specified properties.

The last step of the proof is to provide the parameter restrictions such that there are no demotions and no promotions in which the assignment increases by two levels. Clearly there are no demotions for group 1 workers and no promotions in which the assignment increases by two levels for group 2 workers. Consider first group 1 and the idea that there are no two-level promotions. Using logic like that above that showed that $\theta_1^{+}>\theta_1'$ can be used to show that there is a critical value for promotion to job 3 which is above θ_2'. But by assumption $\theta_1^{H}<\theta_2'$ so there are no two-level promotions, i.e., no additional parameter restrictions are required to rule out two-level promotions.

Now consider group 2 and the idea that there are no demotions. To rule out demotions we assume parameters are such that $\theta_1^{M\prime}<\theta_2^L$. With this restriction if a group 2 worker is assigned to job 1 in period 2 rather than job 2, the market contract offer is unchanged so there is no effect on the utility of the worker if he or she moves. This means the utility the first period employer needs to match is independent of whether the assignment is to job 1 or to job 2. So in deciding whether to assign the worker to job 1 or job 2 at the beginning of period 2, given $\theta_2^L>\theta_1'$, the firm would prefer to assign the worker to job 2 rather than job 1 which means there are no demotions in equilibrium. This completes the proof.

<u>Proof of Corollary 1</u>: From Lemma 1 we have that, if j=k, then the bonus size for old workers equals $s_2d_je_j{}^*(s_2)$. Since $d_2>d_1$ and $e_2{}^*(s_2)>e_1{}^*(s_1)$, we have that old workers on job level 2 with one period of prior experience on the job level have higher bonuses than old workers on job level 1 with one period of prior experience on the job level. From Lemma 1 we also have that, if j=k+1, then the bonus size for old workers equals $s_1d_j(e_j{}^*(s_1))$. Since $d_3>d_2$ and $e_3{}^*(s_1)>e_2{}^*(s_1)$, we have that old workers on job level 3 with zero periods of prior experience on the job level have higher bonuses than old workers on job level 2 with zero periods of prior experience on the job level. This proves the first part of Lemma 1.

Now consider period 1 and group k. From the proof of Proposition 1 we know that $\beta_{kk1}d_k+\delta(\partial EU_{k2}/\partial e_{k1})=c'(e_k{}^*(1))=d_k$. As δ approaches zero this yields that β_{kk1} approaches one. This, in turn, yields that the expected bonus payment for group k workers in period 1 on job level k approaches $d_k[E(\theta^k)-\theta_k{}^L+e_k{}^*(1)]$. Since $d_2>d_1$, $e_2{}^*(1)>e_1{}^*(1)$, and $E(\theta^2)-\theta_2{}^L\geq E(\theta^1)-\theta_1{}^L$, we know $d_2[E(\theta^2)-\theta_2{}^L+e_2{}^*(1)]>d_1[E(\theta^1)-\theta_1{}^L+e_1{}^*(1)]$. This proves the second part of Corollary 1.

<u>Proof of Corollary 2</u>: From Lemma 1 we have that old workers on job level 2 with zero periods of firm level tenure earn a bonus equal to $s_1d_2e_2{}^*(s_1)$, while old workers on job level 2 with one

period of firm level tenure earn a bonus equal to $s_2d_2e_2^*(s_2)$. Since $s_2>s_1$ and $e_2^*(s_2)>e_2^*(s_1)$, we have that for old workers on job level 2 the average bonus payment increases with job level tenure.

Proof of Corollary 3: For workers on job level 2, holding job level tenure constant, the only variation involving worker age concerns group 2 workers assigned to job 2 in period 1 and group 1 workers assigned to job 2 in period 2 each of whom has zero prior periods on the job level. From Lemma 1 we have that the bonus for old workers on job level 2 for whom this is the first period on the level equals $s_1d_2e_2^*(s_1)$. From Lemma 2 we have that the expected bonus for young workers on level 2 for whom this is the first period on the level is less than $d_2[E(\theta^2)-\theta_2^L+e_2^*(1)]$. We know $s_1>1$ and $e_2^*(s_1)>e_2^*(1)$, so a comparison of these expressions tells us that, if s_1 is sufficiently large, then for workers on job level 2 the average bonus payment increases with worker age given job level tenure is held constant.

Proof of Corollary 4: Consider period 1 and worker i in group k. From the proof of Lemma 2 we know that $\beta_{kk1}d_k+\delta(\partial EU_{i2}/\partial e_{i1})=g'(e_k^*(1))=d_k$. Given δ sufficiently small (as is indicated in the set-up of the model), this equation yields $\beta_{kk1}>0$. Given this logic holds for each k, k=1,2, we now have that the bonus rate in period 1 is positive for each job level. But a positive bonus rate for each job level in period 1 immediately yields that for young workers bonus payments increase with output once job level is held fixed (job level tenure does not vary among young workers).

Proof of Corollary 5: Consider period 1 and worker i in group k. From the proof of Lemma 2 we know that $\beta_{kk1}d_k+\delta(\partial EU_{i2}/\partial e_{i1})=g'(e_k^*(1))=d_k$. We also know from the proof of Lemma 2 that a change in δ does not change equilibrium behavior in period 2. So an increase in δ increases $\delta(\partial EU_{i2}/\partial e_{i1})$ which, given the equation above means β_{kk1} decreases. Since $e_k^*(1)$ is unchanged with an increase in δ and all group k workers are assigned to job level k in period 1 independent of δ, we now have that the average bonus payment in period 1 decreases for young workers on job level j, j=1,2.

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Table 1
SUMMARY STATISTICS (STANDARD ERRORS IN PARENTHESES)

Job Level	N	Bonus Payment	Salary	Bonus/Salary	Promoted	Age	Tenure at current level	Tenure at firm	Performance Rating	Performance Rating Available
1	1037	2,643.17	34,411.71	0.075	0.272	35.4	2.1	2.1	1.82	0.64
		(3,077.61)	(8,522.34)	(0.066)	(0.445)	(9.7)	(1.7)	(1.7)	(0.72)	(0.48)
2	1560	3,728.30	40,716.63	0.090	0.254	37.0	2.6	4.6	1.78	0.74
		(3,662.42)	(6,823.56)	(0.073)	(0.435)	(9.1)	(2.1)	(2.8)	(0.62)	(0.44)
3	2546	4,906.18	50,675.19	0.095	0.173	38.6	3.0	6.4	1.59	0.74
		(4,594.66)	(8,289.93)	(0.066)	(0.379)	(8.5)	(2.4)	(3.4)	(0.59)	(0.44)
4	3001	11,311.45	72,586.74	0.145	0.012	41.3	4.2	8.3	1.53	0.67
		(13,145.72)	(15,268.31)	(0.119)	(0.110)	(7.8)	(3.2)	(3.6)	(0.60)	(0.47)
5	284	48,421.73	145,954.10	0.316	0.254	45.9	4.4	9.7	1.60	0.51
		(31,707.32)	(60,317.87)	(0.119)	(0.436)	(7.5)	(3.7)	(3.6)	(0.70)	(0.50)
All	8428	8,156.82	57,843.58	0.117	0.146	39.1	3.3	6.1	1.63	0.69
		(13,192.82)	(26,831.04)	(0.102)	(0.353)	(8.8)	(2.8)	(3.8)	(0.63)	(0.46)

Note. This table displays means and standard deviations of the key variables used in the analysis. The unit of observation is worker-year, and the sample consists of workers who earn a bonus in a given year. However, the statistics for ‘Performance rating’ are calculated using the subsamples of workers for whom performance ratings are available. Bonus payments and salaries are reported in real 1988 dollars, and tenure variables are expressed in terms of years.

Table 2
DETERMINANTS OF THE PROBABILITY OF EARNING A BONUS

Earned a bonus in a given year	Logit				Fixed Effects Logit			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Level=2	0.474***	0.489***	0.370***	0.492***	1.144***	1.474***	1.345***	1.644***
	(0.057)	(0.058)	(0.062)	(0.058)	(0.108)	(0.122)	(0.144)	(0.146)
Level=3	0.999***	1.032***	0.926***	1.035***	2.356***	3.009***	2.874***	3.305***
	(0.055)	(0.057)	(0.060)	(0.057)	(0.152)	(0.195)	(0.218)	(0.253)
Level=4	1.333***	1.384***	1.274***	1.407***	2.544***	3.550***	3.404***	4.003***
	(0.061)	(0.063)	(0.067)	(0.064)	(0.212)	(0.282)	(0.312)	(0.380)
Level=5	1.615***	1.632***	1.484***	1.634***	0.847	1.937*	1.811	2.530**
	(0.128)	(0.128)	(0.133)	(0.128)	(0.970)	(1.118)	(1.171)	(1.291)
Rating=2	-0.715***	-0.710***	-0.708***	-0.719***	-0.580***	-0.578***	-0.573***	-0.616***
	(0.037)	(0.037)	(0.038)	(0.037)	(0.059)	(0.059)	(0.060)	(0.060)
Rating=3	-1.790***	-1.774***	-1.764***	-1.778***	-1.475***	-1.462***	-1.471***	-1.541***
	(0.062)	(0.062)	(0.063)	(0.063)	(0.100)	(0.100)	(0.101)	(0.102)
Rating=4	-2.628***	-2.604***	-2.588***	-2.580***	-2.621***	-2.558***	-2.566***	-2.628***
	(0.288)	(0.288)	(0.287)	(0.289)	(0.532)	(0.548)	(0.546)	(0.549)
Tenure at level=2				0.179***				0.308***
				(0.047)				(0.064)
Tenure at level=3				0.140**				0.389***
				(0.056)				(0.092)
Tenure at level=4				0.079				0.411***
				(0.066)				(0.118)
Tenure at level>=5				-0.103*				0.254
				(0.056)				(0.155)
Average salary increase			0.978***				-0.119	
at current level			(0.255)				(0.543)	
Promoted next year		0.182***	0.261***	0.162***		0.576***	0.628***	0.545***
		(0.052)	(0.054)	(0.053)		(0.085)	(0.088)	(0.087)
Mean of the dependent variable	0.251	0.251	0.260	0.251	0.400	0.400	0.401	0.400
N (Worker-year)	23,330	23,330	21,954	23,330	12,053	12,053	11,753	12,053

Log-likelihood	-11244	-11238	-10755	-11220	-4113	-4087	-3986	-4068
Pseudo-R^2	0.144	0.145	0.145	0.146	0.137	0.142	0.143	0.146

Note. This table displays the results of a logit model with the dependent variable indicating whether the worker earns a bonus in a given year. All pooled logits contain controls for the worker's age, gender, race, education level, and year dummies. Huber-White standard errors are reported in parentheses. 'Level= 1', 'Rating=1' and 'Tenure at level=1' are the omitted categories.

*** p<0.01.

** p<0.05.

* p<0.1.

Table 3
VARIATION IN BONUS PAYMENTS EXPLAINED BY JOB LEVELS, AGE AND JOB LEVEL TENURE
(POOLED OLS)

Logarithm of Bonus Payments	(1)	(2)	(3)	(4)	(5)
Level=2	0.433***		0.428***		0.413***
	(0.025)		(0.025)		(0.024)
Level=3	0.719***		0.711***		0.679***
	(0.023)		(0.024)		(0.023)
Level=4	1.423***		1.415***		1.347***
	(0.025)		(0.025)		(0.024)
Level=5	2.955***		2.960***		2.940***
	(0.045)		(0.045)		(0.045)
Age		0.156***	0.021***		-0.001
		(0.008)	(0.007)		(0.007)
$Age^2/100$		-0.167***	-0.028***		-0.011
		(0.010)	(0.008)		(0.008)
Tenure at level=2				0.227***	0.180***
				(0.024)	(0.018)
Tenure at level=3				0.389***	0.259***
				(0.029)	(0.020)
Tenure at level=4				0.508***	0.289***
				(0.034)	(0.023)
Tenure at level>=5				0.719***	0.440***
				(0.026)	(0.020)
N(Worker-Years)	8,428	8,428	8,428	8,432	8,428
Adjusted R^2	0.521	0.062	0.522	0.097	0.547
Log-likelihood	-7631	-10462	-7620	-10304	-7392
Test statistics					
Significance of job levels	1924		1820		1771
p-value	<0.000		<0.000		<0.000
Zero age semi-elasticity		302.5	12.12		0.38
p-value		<0.000	<0.000		0.54
Significance of job level tenure				215.5	122.7
p-value				<0.000	<0.000

Note. This table displays the results of linear regression models with the dependent variable being the logarithm of bonus payments in 1988 dollars. Huber-White standard errors are reported in parentheses, and they are corrected to account for the intraworker correlation. ‘Level= 1’ and ‘Tenure at level=1’ are the omitted categories. The bottom panel includes three tests. The first one is an F-test where the null hypothesis is that coefficient on job level dummies are jointly not significant. The second is an F-test where the null hypothesis is that the age semi-elasticity of bonus payment evaluated at $\overline{age}$, the age of the average worker, is zero. The third one is an F-test where the null hypothesis is that coefficient on job level tenure dummies are jointly not significant. <0.000 means that the corresponding p-value is smaller than 0.0005.

*** p<0.01.

** p<0.05.

* p<0.1

Table 4
VARIATION IN BONUS PAYMENTS EXPLAINED BY JOB LEVELS, AGE AND JOB LEVEL TENURE
(FIXED-EFFECTS)

Logarithm of Bonus Payments	(1)	(2)	(3)	(4)	(5)
Level=2	0.445***		0.317***		0.411***
	(0.058)		(0.059)		(0.064)
Level=3	0.628***		0.351***		0.551***
	(0.067)		(0.074)		(0.093)
Level=4	0.905***		0.484***		0.820***
	(0.075)		(0.090)		(0.130)
Level=5	1.457***		0.941***		1.450***
	(0.128)		(0.131)		(0.205)
Age		0.368***	0.292***		0.186***
		(0.033)	(0.035)		(0.043)
$Age^2/100$		-0.368***	-0.304***		-0.215***
		(0.038)	(0.039)		(0.045)
Tenure at level=2				0.082***	0.120***
				(0.020)	(0.024)
Tenure at level=3				0.169***	0.199***
				(0.025)	(0.033)
Tenure at level=4				0.153***	0.183***
				(0.031)	(0.044)
Tenure at level>=5				0.132***	0.203***
				(0.034)	(0.054)
N(Worker-Years)	8,428	8,428	8,428	8,432	8,428
Adjusted R^2	0.802	0.806	0.812	0.782	0.816
Log-likelihood	-1290	-1218	-1082	-1708	-994.6
Test statistics					
Significance of job levels	44.54		14.94		15.42
p-value	<0.000		<0.000		<0.000
Zero age semi-elasticity		109.1	66.42		20.68
p-value		<0.000	<0.000		<0.000
Significance of job level tenure				11.77	9.68
p-value				<0.000	<0.000

Note. This table displays the results of linear regression models with the dependent variable being the logarithm of bonus payments in 1988 dollars. Huber-White standard errors are reported in parentheses, and they are corrected to account for the intraworker correlation. ‘Level= 1’ and ‘Tenure at level=1’ are the omitted categories. The bottom panel includes three tests. The first one is an F-test where the null hypothesis is that coefficient on job level dummies are jointly not significant. The second is an F-test where the null hypothesis is that the age semi-elasticity of bonus payment evaluated at $\overline{age}$, the age of the average worker, is zero. The third one is an F-test where the null hypothesis is that coefficient on job level tenure dummies are jointly not significant. <0.000 means that the corresponding p-value is smaller than 0.0005.

*** p<0.01.

** p<0.05.

* p<0.1

Table 5. DETERMINANTS OF BONUS PAYMENTS

	A. Pooled OLS				B. Fixed-Effects			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Level=2	0.412***	0.353***	0.404***	0.363***	0.317***	0.187**	0.411***	0.275***
	(0.024)	(0.030)	(0.023)	(0.029)	(0.059)	(0.073)	(0.064)	(0.084)
Level=3	0.671***	0.624***	0.655***	0.617***	0.351***	0.207**	0.551***	0.371***
	(0.023)	(0.029)	(0.023)	(0.029)	(0.074)	(0.090)	(0.093)	(0.123)
Level=4	1.289***	1.181***	1.247***	1.154***	0.484***	0.287**	0.820***	0.551***
	(0.026)	(0.032)	(0.025)	(0.032)	(0.090)	(0.113)	(0.130)	(0.176)
Level=5	2.741***	2.514***	2.751***	2.542***	0.941***	0.579	1.450***	0.927**
	(0.046)	(0.063)	(0.046)	(0.062)	(0.131)	(0.371)	(0.205)	(0.458)
Age	0.015**	0.013*	-0.007	-0.008	0.292***	0.259***	0.186***	0.185***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.035)	(0.049)	(0.043)	(0.058)
$Age^2/100$	-0.020***	-0.016*	-0.003	0.001	-0.304***	-0.282***	-0.215***	-0.218***
	(0.008)	(0.009)	(0.008)	(0.009)	(0.039)	(0.055)	(0.045)	(0.060)
Rating=2		-0.091***		-0.123***		-0.072***		-0.084***
		(0.016)		(0.015)		(0.024)		(0.024)
Rating=3		-0.017		-0.090***		-0.173***		-0.189***
		(0.033)		(0.034)		(0.056)		(0.055)
Rating=4		0.456**		0.397*		-0.556		-0.527
		(0.230)		(0.222)		(0.477)		(0.457)
Tenure at level=2			0.171***	0.157***			0.120***	0.095***
			(0.017)	(0.021)			(0.024)	(0.032)
Tenure at level=3			0.249***	0.240***			0.199***	0.148***
			(0.020)	(0.023)			(0.033)	(0.043)
Tenure at level=4			0.283***	0.271***			0.183***	0.140**
			(0.022)	(0.027)			(0.044)	(0.057)
Tenure at level>=5			0.412***	0.370***			0.203***	0.115
			(0.020)	(0.024)			(0.054)	(0.076)
Constant	7.464***	7.539***	7.897***	7.992***	1.637**	2.725***	4.015***	4.348***
	(0.137)	(0.177)	(0.137)	(0.179)	(0.735)	(1.043)	(0.933)	(1.264)
No. of Worker-Years	8,428	5,851	8,428	5,851	8,428	5,851	8,428	5,851

Adjusted R^2	0.564	0.534	0.585	0.552	0.812	0.846	0.816	0.848
Log-likelihood	-7231	-4918	-7015	-4798	-1082	684.4	-994.6	730.5
F-test: H0 $\delta j=0$ for all j.	1306	672.5	1306	675.6	14.94	2.254	15.42	3.148
p-value	0	0	0	0	0	0.0610	0	0.0136
F-test: H0 $\gamma 1+\overline{age}*\gamma 2/50=0$	6.382	3.184	0.118	0.374	66.42	27.13	15.42	3.148
p-value	0.0115	0.0744	0.731	0.541	0	2.02e-07	0	0.0136

Notes: This table displays the results of estimating Equation (2). The dependent variable is the logarithm of bonus payments in 1988 dollars. Panel A reports the results for the pooled OLS, and Panel B reports the results of the fixed-effects estimation. Standard errors reported in parentheses are obtained using the Huber-White sandwich estimator. All pooled regressions include race, education and year dummies. 'Level= 1' is the omitted category. $\overline{age}$ denotes the age of the average worker.

*** $p<0.01$.

** $p<0.05$.

* $p<0.1$

Table 6
THE TRADE-OFF BETWEEN BONUS PAYMENTS AND EXPECTED PROMOTION PRIZE

Logarithm of bonus payments	(1)	(2)	(3)	(4)	(5)
Panel A.					
Promotion prize A	-2.283***	-2.371***	-1.779***	-2.288***	-1.897***
	(0.267)	(0.268)	(0.316)	(0.298)	(0.351)
Corrected standard error	[0.3967]	[0.400]	[0.466]	[0.425]	[0.506]
p-value with corrected standard error	<0.000	<0.000	<0.000	<0.000	<0.000
N(Worker-Years)	5,807	5,807	5,807	5,668	5,668
Adjusted R^2	0.534	0.538	0.548	0.524	0.548
Log-likelihood	-4845	-4819	-4761	-4702	-4561
Panel B.					
Promotion prize B	-2.336***	-2.398***	-1.540***	-2.350***	-1.618***
	(0.287)	(0.288)	(0.327)	(0.321)	(0.364)
Corrected standard error	[0.422]	[0.425]	[0.473]	[0.467]	[0.509]
p-value with corrected standard error	<0.000	<0.000	0.001	<0.000	0.001
N(Worker-Years)	5,341	5,341	5,341	5,202	5,202
Adjusted R^2	0.513	0.517	0.526	0.502	0.524
Log-likelihood	-4453	-4433	-4378	-4311	-4192
Panel C.					
Promotion prize C	-2.469***	-2.538***	-1.599***	-2.539***	-1.735***
	(0.293)	(0.295)	(0.340)	(0.331)	(0.380)
Corrected standard error	[0.432]	[0.437]	[0.491]	[0.478]	[0.537]
p-value with corrected standard error	<0.000	<0.000	0.001	<0.000	0.001
N(Worker-Years)	5,341	5,341	5,341	5,202	5,202
Adjusted R^2	0.513	0.517	0.526	0.503	0.524
Log-likelihood	-4450	-4429	-4378	-4307	-4190
Explanatory Variables					
Performance ratings	No	Yes	No	No	Yes
Tenure at current level	No	No	Yes	No	Yes
Average salary increase at current job level	No	No	No	Yes	Yes

Note: This table displays the results of estimating equation (8) where three different expected promotion prizes are employed. To construct expected promotion prize, we estimate equation (5) and equation (6) (details provided in the text). The set of explanatory variables for estimating equation (5) includes the worker's age, job level, tenure at current level, performance ratings, and worker fixed-effects for 'Promotion prize A'; the same variables (except for worker fixed-effects) and education level, gender, tenure at the firm for 'Promotion prize B'; and for 'Promotion prize C' we add job titles to the second set of control variables. The set of explanatory variables for estimating equation (6) includes the worker's age, gender, job level, tenure at the current job level, indicator variables for education categories, and the worker's relative performance rating The dependent variable is the logarithm of bonus payments in 1988 dollars. All regressions include controls for the worker's age, race, gender, education level, job level and year in which the bonus is paid. Standard errors reported in parentheses are obtained using the Huber-White sandwich estimator, and they are corrected for the intraworker correlation. Corrected standard errors reported in brackets are obtained using a non-parametric bootstrap method, which is explained in the text. p-value refers to the two-tailed test for the significance of 'Promotion prize' using the corrected standard error. *** p<0.01; ** p<0.05; * p<0.1.

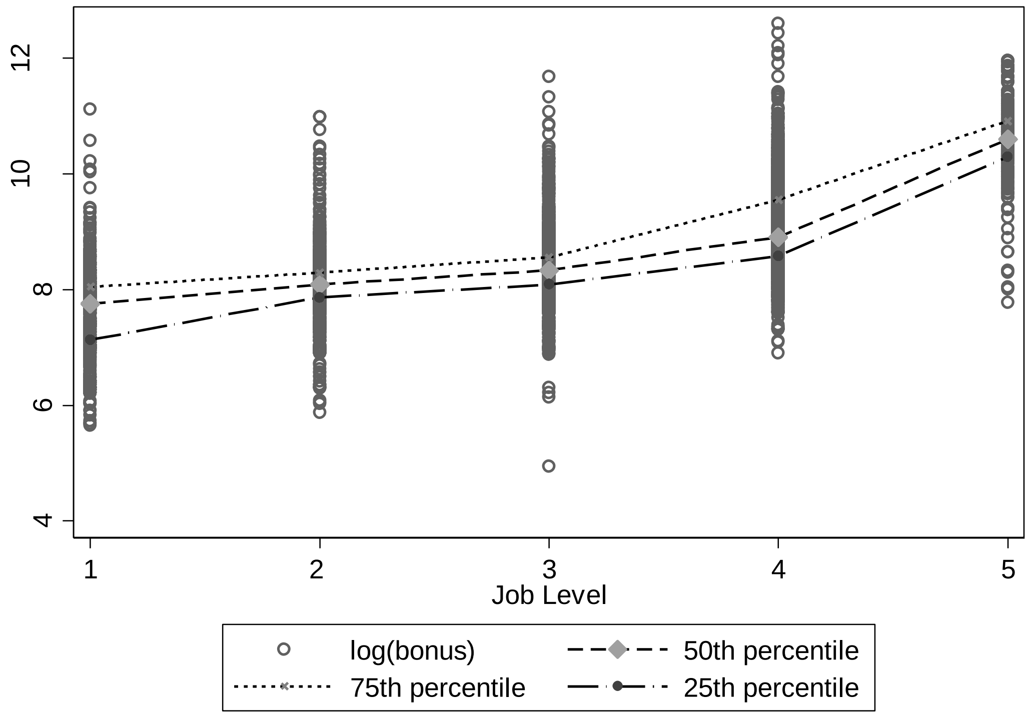

Figure 1. The distribution of bonus payments by job level. This figure plots the distribution of the log of bonus payments (in 1988 dollars) by job level. Bonus payments at the 25th, 50th and 75th percentiles are indicated for each job level.

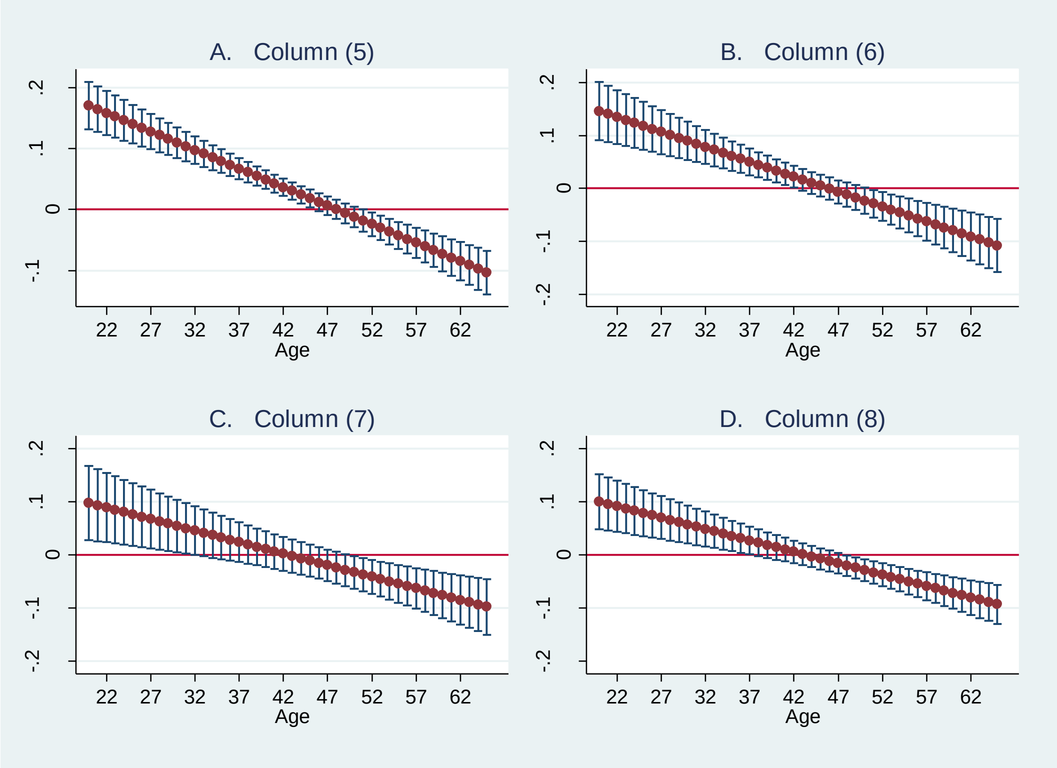

Figure 2. Age semi-elasticity of bonus payments with 95% confidence bands. This figure plots the semi-elasticity of bonus payments with respect to age. Age-semi elasticity of bonus payments is given by γ_1+age*γ_2/50, and the point estimates for γ_1 and γ_2 that are used to calculate the age-semi elasticity come from the fixed-effects regression results reported in Table 5.