

ESSAYS ON PERSONNEL ECONOMICS

A Dissertation

Presented to the Faculty of the Graduate School
of Cornell University
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy

by

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August 2012

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ESSAYS ON PERSONNEL ECONOMICS

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Cornell University 2012

This dissertation is a collection of three essays on personnel economics.

The first essay studies bonus payments in a hierarchical firm. A well-documented finding in the internal labor markets literature is that the size of bonus payments increases as one moves up the corporate ladder. Two existing theories that can be used to explain this finding cannot fully capture the empirical patterns of the size of bonus payments. I develop a unified framework that can better match the empirical findings. Using a dynamic tournament model augmented with an asymmetric learning structure in which the current employer has an informational advantage over its competitors regarding the worker's productivity, my model offers an economic rationale for the employer's decision on the size of bonus payments by identifying two counteracting mechanisms that determine bonuses. Specifically, the size of bonus payments increases with the level of effort the employer aims to induce, but decreases with the size of the worker's career-concern incentives. I test the model's predictions using data from the personnel records of a medium-sized firm in the financial services industry. The results provide direct evidence for the model's predictions.

The second essay investigates how salaries and bonus payments are related to turnover. In contrast with the existing literature, this study treats bonus payments as a distinct type of compensation, rather than aggregating them with salaries. The first part of the empirical analysis focuses on data coming from the personnel records

of a medium-sized U.S. firm. I find that earning a bonus in the current period, as well as the size of the bonus, is negatively related to the probability of turnover after controlling for the size of salary or the growth rate of salary. These results also indicate that the growth rate of salary is negatively related to turnover, while results concerning the effect of the size of salaries are mixed. The second part of the empirical analysis uses a sample drawn from the Panel Study of Income Dynamics (PSID). The results show that salary, both in terms of size and growth rate, has a negative effect on the probabilities of quits and layoffs; whereas the negative effect of bonus payments is more evident in layoffs than quits.

This third essay examines conditions under which employee referrals serve a screening function. Unlike the existing theoretical work, the possibility of a conflict of interest arising between the firm and current employees during the referral process is investigated. I consider two potential mechanisms that lead to a conflict of interest. First, I examine how the employee's social connections relate to his referral decision. I show that the employee finds it optimal to refer applicants with whom he has a strong social connection rather than applicants of high ability. Second, I examine how the employee's promotion prospects affect his referral decisions. Specifically, I posit that the current employee will have incentives to refer an applicant of lower ability if he faces any possibility of competition for promotions between himself and the newly hired worker. In either of these situations, employee referrals may not provide screening of more able workers. Finally, I show that the firm can make use of referral bonuses, which are contingent on the referral's performance, to align incentives of the employee with those of the firm.

BIOGRAPHICAL SKETCH

Emre Ekinçi was born in Istanbul, Turkey on June 11, 1982. He received his Bachelor of Arts degree in Economics from Koç University, Turkey in 2005, and his Master of Arts degree in Economics, also from Koç University, in 2007. He began his graduate studies in economics at Cornell University in August 2007. His primary research focus has been in Labor Economics and Organizational Economics. In September 2012, Dr. Ekinçi will be joining the Department of Business Administration at Universidad Carlos III de Madrid, Spain as an Assistant Professor.

To my family

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to my advisor, Professor Michael Waldman, whose expertise, understanding, support, and patience made this dissertation possible.

I would like to thank the other members of my committee, Professors Kevin F. Hallock and Francine D. Blau, who provided significant support and guidance that contributed to the completion of this dissertation.

I am also very grateful to Professor Michael Gibbs for providing some of the data used in this dissertation, and to Professor George Jakubson for helpful discussions. I thank my fellow graduate students at the Institute of Compensation Studies (ICS) and all members of the Economics community at Cornell, who enriched my graduate school experience.

I will forever be thankful to my former research advisor, Professor İnan Tunali, who helped me matriculate at Cornell.

I also thank Aziz Simsir, Kemal Ozbek, Berk Esen, Ahmed Jaber, and Yasin Alan for their friendship and support.

Finally, this thesis would not have been possible without the love, encouragement, and patience of my family.

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CHAPTER 1
BONUS PAYMENTS IN A CORPORATE HIERARCHY: THEORY
AND EVIDENCE

1.1 Introduction

Incentives to workers within a corporate hierarchy are provided in various forms; explicit incentives come with the compensation package a job entails, whereas implicit incentives are embedded in the job itself in the form of potential future benefits. The firm, which has the authority to direct resources in the most favorable way according to its objectives, needs to provide the ‘best’ mixture of incentives to elicit optimal performance from its employees. Hence, it is very hard, if possible, to analyze one form of incentives thoroughly without any reference to its relations to others. By taking this perspective, the current paper scrutinizes how bonuses are aligned with other forms of incentives in a hierarchical firm.

One empirically well-documented finding about bonuses is that the size of bonus payments increases as one moves up the hierarchy (e.g., Lambert, Larcker, and Weigelt, 1993; Baker, Gibbs, and Holmstrom, 1994a,b; Smeets and Warzynski, 2008). However, the economic rationale behind this finding is not well understood. Hence, this paper attempts to shed light on this issue by studying how bonus contracts are determined in a hierarchical firm. In doing that, the model incorporates two separate strands in the literature that examine performance-pay contracts. The first

one focuses on the most evident function of performance-pay contracts, which is to implement the efficient level of effort, and examines how the size of performance-pay contracts is related to the level of effort the employer aims to induce. The second one focuses on the career-concern incentives of workers that result from the market's gradual learning about the worker's ability, and examines how the presence of career-concern incentives affects compensation contracts. As will be shown, the theoretical model that adapts these two incentive mechanisms for a corporate hierarchy better explains the empirical patterns than either of the two can do on its own. Therefore, this paper primarily attempts to reconcile the theory of bonus contracts with the empirical findings regarding the size of bonus payments in a corporate setting.

In the first part of the paper, I develop a theoretical model in which incentive effects of bonuses can be examined in conjunction with the worker's career-concern incentives. In doing that, the paper develops a theoretical framework in which a clear distinction is made between functions of salary and bonuses, and both explicit incentives from bonuses and career-concern incentives are incorporated. Accordingly, bonuses are used to implement the efficient level of effort, whereas the size of salary is determined to ensure that wage offers made by competing firms do not surpass the wage contract offered by the current employer. The worker's career-concern incentives arise from the asymmetric learning structure between the current employer and potential employers regarding the worker's productivity. The model yields three predictions regarding how bonus payments are related to job levels and career-concern incentives of the worker. These predictions are used to distinguish the current model from two competing theories that can also be used to explain

why bonuses increase with job level. The second part of the paper uses personnel data from a medium-sized hierarchical firm to investigate the extent to which these predictions are consistent with the data. The empirical analysis suggests that the model proposed in the current paper better matches the data than the competing explanations.

As the theoretical model will demonstrate, incentives provided to a worker who is employed in a hierarchical firm are not limited to her compensation contract. Consider a worker whose compensation contract includes a base salary and a bonus contingent on her performance. The compensation contract provides the worker with incentives to put forth effort. Besides the compensation contract, however, the worker is also provided with implicit incentives due to the hierarchical structure of the firm. The fact that the worker enjoys higher wages as she climbs up the job ladder provides her with incentives to exert more effort. Moreover, the worker also has incentives to improve wage offers made by potential employers since they in turn determine her compensation contract at the current firm. Therefore, the bonus contract should be examined within the incentive structure of the hierarchical firm which, as the discussion demonstrates, is not limited to the compensation contract alone.

Having argued that different forms of incentives provided to the worker should be examined jointly, I develop a theoretical framework that incorporates different incentives. Borrowing the terminology of Gibbons and Murphy (1992), who study the career-concern incentives of CEOs, I assume that the worker's explicit incen-

tives come from the bonus contract, as in their work. To incorporate the career-concern incentives, an asymmetric learning structure between the current employer and potential employers is employed (e.g., Zabochnik and Bernhardt, 2001; Ghosh and Waldman, 2010). Hence, not only the bonus contract but also the fact that the worker can earn higher wages by improving the current employer's perception about her ability (thereby improving the market's perception through promotions) provides the worker with the implicit incentives to exert effort. Note that implicit incentives are not a part of the wage contract, but they result from the employer's gradual learning about the worker's ability. Finally, as there are multiple periods with hierarchical job levels in the model, it builds upon Rosen's (1986) multi-stage elimination tournament model. This framework will help examine how bonuses are related to other forms of incentives, and offers a rationale for why bonuses increase with hierarchical level.

To model a corporate hierarchy in which the possibility of upward mobility generates career-concern incentives for workers, I employ the tournament approach where prizes are endogenously determined via the competition in the labor market. Unlike the early generation of tournament models in which the employer sets prizes to elicit optimal effort from its employees (Lazear and Rosen, 1981), the approach used here makes use of an asymmetric information structure between the current employer and potential employers about the worker's ability level in order to generate competition to raid more productive workers.¹ In this setup, the current employer revises its

¹See Waldman (2011) for a comparison of the two approaches to modeling promotion tournaments.

beliefs about a worker's ability after observing the worker's output, and it makes a promotion decision which serves as a signal of the worker's ability to the market (Waldman, 1984). Consequently, the promotion premium (and also any 'punishment' for being passed over for a promotion decision) is determined by the market demand for the worker. Even though the current employer has an informational advantage over its competitors regarding the worker's productivity, it does not have direct control over prizes associated with promotions.²

Bonuses are incorporated into the model by imposing a wage contract which is composed of a base salary and a bonus contingent on worker performance. The worker earns a bonus each period if the level of her output meets a threshold output level, which is determined in accordance with the production limits at the corresponding job level. As promised, both explicit and implicit incentives are embedded in the model. The worker is provided with explicit incentives through the compensation package, which includes a base salary and a bonus based on individual performance, and implicit incentives through promotions and wage offers made by potential employers.

The model shows that the bonus contract used by the employer to implement the efficient level of effort is determined by two counteracting mechanisms. First, returns to ability at a given job level determine the efficient level of effort. Therefore,

²Starting with the seminal work of Gibbons and Katz (1992), there is a large body of empirical literature that tests asymmetric learning in labor markets. Recent empirical work that finds supporting evidence of asymmetric learning includes Kahn (2009), Pinkston (2009), and Hu and Taber (2011). DeVaro and Waldman (2012) focus on the promotion-as-signal hypothesis and find supporting evidence for workers with bachelors and master degrees, and mixed evidence for high-school graduates and PhDs.

as returns to ability increase with job level, the employer offers higher bonuses to workers assigned to higher job levels. This feature of the model is in line with Lemieux, MacLeod, and Parent (2009) who show that the performance-pay increases with the returns to effort. Second, the career-concern incentive of the worker reduces the bonus contract. This follows from the feature of the optimal contract which is to balance between explicit and implicit incentives provided to the worker (Gibbons and Murphy, 1992). The size of the career-concern incentive depends on the worker's job level and age, thus its effect on the bonus contract changes with job level and age. Accordingly, the first two predictions derived by assessing the effects of the two mechanisms on the bonus contract compare the size of bonus payments across job level and age, while the third one focuses on the relation between the bonus contract and the career-concern incentives of the worker. The testable predictions of the model are as follows: i) controlling for age, bonus payments increase with job level; ii) holding job level constant, bonus payments increase with age; and iii) the bonus payment in the current period is negatively related to the expected prize for promotion.

The implication of the first prediction is that bonuses paid to workers of the same age group increase with job level. To illustrate the intuition behind this prediction, compare two middle-aged workers at different job levels. Two counteracting mechanisms affect the size of bonus payments for the middle-aged worker. First, as returns to ability are greater at the higher job level, the efficient level of effort is also higher at the same job level. Therefore, the employer offers a larger bonus contract to the worker at the higher job level. Second, the worker at the higher job level has stronger

career-concern incentives to put forth effort, thus she is offered lower bonuses. I show that the first effect dominates the second effect, so that the worker at the higher job level is offered a larger bonus contract. For old workers, however, only the first effect, that is returns to ability increase with job level, drives the result. This is due to the fact that old workers do not have incentives from career concerns since their career prospects are limited.

The second prediction states that among workers at the same job level, older ones are eligible for higher bonuses. The intuition behind this prediction is similar to the argument made by Gibbons and Murphy (1992). Workers who are close to retirement have weaker career-concern incentives since they have fewer opportunities for promotions, and also fewer periods to collect future benefits. Therefore, their wage contracts must include higher bonuses to maintain incentives to induce the efficient level of effort. Note that since workers in comparison are assumed to be at the same job level in this prediction, returns to ability are the same for them. Hence, the disparity in career-concern incentives remains as the only effect that implies bonuses of different sizes.

The third prediction stems from the tradeoff between explicit and implicit incentives provided to the worker. Note that a worker who is promoted to the next job level experiences an increase in her expected compensation for the next period. Therefore, the possibility of earning a promotion provides the worker with implicit incentives to exert effort in the current period. As will be discussed in detail, the optimal contract balances incentives provided through the bonus contract and in-

centives provided through the possibility of promotions. Therefore, if the increase in the expected compensation in the next period gets larger, the employer reduces the bonus contract as a response. Lazear and Rosen (1981) show that the prize for promotion (that is, the wage spread between the winner and the loser of a given tournament) can be used to induce the efficient effort level. The logic of this prediction is consistent with their argument, yet its focus is different. Accordingly, this prediction maintains that the composition of incentives provided to the worker can be changed without altering the efficient level of effort.

The second part of the paper tests the empirical predictions using personnel data from a medium-sized hierarchical firm. The same data was first analyzed by Baker, Gibbs, and Holmstrom (1994a,b) in their influential studies that gave a very detailed examination of the internal organization and pay dynamics of the firm.³ The original data are a 20-year unbalanced panel of all managerial employees in one firm; however, I will use its last 7-year sub-period in which bonus data is available. This data set is well-suited for the purposes of the current paper because in addition to having information on salary, bonus and performance ratings, it also includes detailed information on the firm's hierarchy that Baker, Gibbs and Holmstrom constructed using the raw data on job titles and typical movements across job titles.

As the theoretical model demonstrates, in equilibrium more able workers are assigned to higher job levels. This may bias the point estimates of job levels since presumably more able workers earn higher bonuses. To address this potential bias, I

³Other studies that employ the same data set include Gibbs (1995), Kahn and Lange (2010), and DeVaro and Waldman (2012).

exploit the panel aspect of the data by employing a fixed-effects specification. This estimator will eliminate selection bias operating through a time-invariant worker-specific heterogeneity term. To illustrate the effects of worker heterogeneity on parameter estimates, I report the ordinary least-squares regression results as a benchmark. As will be discussed in detail, the detailed information about workers' performance ratings and job histories enables me to further check the robustness of the results.

The empirical analysis provides supporting evidence of the model's prediction. Specifically, regression results show that the size of bonus payments increases with job level even when one controls for the worker's age, and that the size of bonus payments increases with the worker's age after controlling for job level. As for the third prediction, the results indicate that an increase in the expected prize for a promotion in the next period leads to a decrease in bonuses earned in the current period. Therefore, they suggest a trade-off between the worker's explicit incentives from bonuses and her implicit incentives that arise from the possibility of promotions.

Note that the empirical support for the predictions implies that the theoretical model developed in this paper better matches the data than the competing theories in the literature. In particular, the idea that returns to ability determine the size of bonuses cannot explain why bonuses in a given job level increase with the worker's age, while the idea of career-concern incentives cannot explain why bonuses increase with job level after controlling for the worker's age. The third prediction, on the other hand, combines the basic results of the baseline tournament model and the

career-concerns model. Hence, it offers a novel prediction regarding the interplay between bonus-based and promotion-based incentives.

The rest of the paper is organized as follows. Section 2 discusses related work in the literature. The theoretical model is presented in Section 3, which includes the analysis of the model and a discussion of its testable implications. Section 4 describes the data used in the empirical analysis. Section 5 begins with a preliminary analysis of the firm's bonus policy, and then it discusses econometric specifications to test the predictions and the subsequent results. Section 6 concludes the paper.

1.2 Related Literature

Stemming from the seminal analysis of Lazear and Rosen (1981), the literature on the tournament approach to internal-labor-market compensation has grown enormously.⁴ Among others, two important extensions to the benchmark tournament approach are the main ingredients of the framework presented in this paper. The first extension is Rosen's (1986) multi-stage tournament model, and the second extension is the one that incorporates market demand into the determination of prizes (Zabojnik and Bernhardt, 2001; Ghosh and Waldman, 2010).

In their benchmark model, Lazear and Rosen (1981) consider a single firm that establishes a tournament for two risk-neutral identical workers. Since workers' effort

⁴For a detailed discussion of the tournament literature and references to early works, see Gibbons and Waldman (1999), Prendergast (1999), Waldman (2010), Lazear and Oyer (2010), and references therein.

choices are not observable by the firm, it employs a compensation scheme that is based on workers' output levels. Accordingly, the firm commits to prizes for the winner and the loser of the tournament, where the winner is the worker who produced more than the other worker. By choosing the difference between the two wages, i.e., the spread, the firm can implement the efficient level of effort.

Since I consider multiple levels, the approach used to model promotions in this paper is closest in spirit to that of Rosen (1986) who extends the benchmark tournament model to multiple levels. Rosen's model has a single elimination tournament with a single winner at the end of the tournament. In that setup, each round can be interpreted as a competition for promotions. Assuming identical risk-neutral workers exerting the same constant effort level from round to round, he shows that prizes for promotions (i.e., the spread between the winner's and the loser's wages in a given round) are constant, except in the last round where there is a discretely higher prize. A number of important differences between the two models needs to be emphasized. First, in Rosen's model there are not different jobs with different production technologies. Therefore, promotions do not lead to a change in tasks to be performed by the winner of a given round or to different efficient effort levels. Second, he assumes the firm can commit to future prizes associated with promotions. As discussed in more detail below, my model has an asymmetric learning structure that leads to wage increases upon promotions being endogenously determined via the labor market. Finally, Rosen's model does not have any type of performance pay, including bonuses, which is the main focus of the current paper. Consequently, my model builds upon Rosen's, and it extends his results in two ways. First, promotions serve both as a

sorting mechanism, in which more able workers are assigned to jobs that have higher returns to ability, and as an incentive mechanism, in which wage increases upon promotions provide implicit incentives to the worker to exert more effort. Second, consistent with the empirical evidence, the result that prizes for promotions increase with job level is not confined to the very last level.

Having an asymmetric learning structure between the current employer and potential employers has two roles in the model proposed in this paper. First, it incorporates labor market demand into the determination of prizes associated with promotions. The current employer privately observes the output realization of the worker, and makes a promotion decision. Potential employers that cannot observe the worker's output use the promotion decision as a signal of the worker's ability, and make wage offers consistent with the signal. As a result, workers who are promoted receive higher wage offers that the current employer has to match to retain the worker. Unlike the early tournaments models, the current employer cannot commit to future prizes associated with promotions since they are determined via the labor market demand for the worker.

In this regard, the model proposed in the current paper is similar to that of Zabojnik and Bernhardt (2001) and Ghosh and Waldman (2010), yet both papers have different foci and major differences as well. Zabojnik and Bernhardt (2001) use a model in which workers choose the level of human capital accumulation that can affect their probability of winning a promotion to offer an explanation to the firm-size wage effect and inter-industry wage differentials. In Ghosh and Waldman

(2010), on the other hand, promotions serve as incentives for worker effort and to allocate workers to jobs according to their capabilities. Using this approach, they attempt to shed light on the choice between standard promotion practices and up-or-out contracts. However, the current model departs from them in an important way; accordingly, the current model indicates that the employer can use bonus contracts to implement the efficient level of effort, whereas the efficient level of effort (or, the efficient level of human capital investment) may not be possible to induce in their models.

The second role of the asymmetric learning structure is to provide career-concern incentives to the worker.⁵ In this regard, the most relevant work is by Gibbons and Murphy (1992) who examine how career concern incentives affect performance pay contracts. To do so, they employ the idea of symmetric learning in which all labor market participants, including potential employers, observe the output realization of the worker and use that additional information to update their beliefs about the worker's ability.⁶ They show that the optimal wage contract should optimize implicit incentives, which arise from career concerns, and explicit incentives from the compensation contract, by making one stronger when the other one is weaker. One

⁵The idea that the worker has implicit incentives was first proposed by Fama (1980) and Holmstrom (1999), and it is called career concerns in the literature. This strand of the literature maintains that the worker has incentives to exert effort not just to maximize her contemporaneous benefits but also to affect the market's perception regarding her unobserved skills in order to improve her future benefits. Workers improve the market's perception by producing high output levels which are publicly observable in their approach. In that sense, employing an asymmetric learning structure yields results consistent with their argument since the output is privately observed by the current employer, but promotion decisions are observed by all labor market participants.

⁶Andersson (2002) extends their model by examining the case in which potential employers that do not observe wage contracts use incomes to estimate the worker's ability level, and shows that the worker's effort is distorted upward and the distortion positively depends on turnover.

empirical implication of this argument is that performance pay should increase with age since workers close to retirement have weaker career concern incentives. Using data on CEO compensation, they find supporting evidence for this hypothesis.

My theoretical model contrasts with that put forward by Gibbons and Murphy (1992) in three major ways. First, they assume symmetric learning about the worker's ability, whereas I employ asymmetric learning as discussed above. Their second crucial assumption is workers are risk-averse. Indeed, career concerns would be entirely eliminated by optimal contracts if workers were assumed to be risk neutral in their model. My model, on the contrary, shows that career concerns still arise even with risk neutral workers, owing to the presence of the asymmetric learning mechanism. Third, they do not model promotions, thus there is a single job at which the worker remains throughout her career.

Lemieux, MacLeod, and Parent (2009) study how the prevalence of performance-pay contracts can affect wage inequality. Even though their main focus is not relevant to the current paper, their theoretical model offers a potential explanation for why bonuses increase with job level. Their model focuses on how firms choose between performance-pay contracts and fixed-wage contracts. Accordingly, at the time of hiring firms have very limited information about the worker's ability, which may result in a mismatch between the worker's capabilities and the employer's expectations. The use of performance-pay contracts can mitigate the loss in productivity that results from this mismatch. The introduction of this type of contract is not costless, though, since it requires monitoring workers' performance that eventually

determines their payments. Hence, the employer chooses performance-pay contracts over fixed-wage contracts when the gain in productivity resulting from the use of the former exceeds its cost.⁷ They derive testable implications from the model, and test them using the Panel Study of Income Dynamics.

One implication of their model is that wages given a performance-pay job increase with the returns to effort. Using the observation that returns to effort are higher at higher job levels (Rosen, 1982), this argument can be extended to explain why bonuses increase with job level. That is to say, bonuses increase with job level because returns to effort increase with job level and pay tied to performance increases with returns to effort.

There are thus two competing theories that can also explain why bonuses increase with job level. First, the argument made by Gibbons and Murphy (1992) implies that bonuses go up with job level because workers at higher job levels are older on average, and therefore they must be compensated for lack of, or diminished, career-concern incentives. However, as a distinguishing feature, the current model yields the testable prediction that bonuses increase with job level even if age is held constant. Second, as Lemieux, MacLeod, and Parent (2009) demonstrate in their model, as returns to effort are greater at higher job levels the employer will offer bonuses of larger size to workers at higher job levels. However, contrary to the implication of their argument that all workers at the same job level are eligible for bonuses of the same size since returns to effort are the same, the current model shows that workers

⁷This argument was originally proposed by Lazear (1986).

at the same job level may be eligible for bonuses of different sizes due to disparities in their career-concern incentives. More specifically, it indicates that older workers are eligible for higher bonuses than their counterparts at the same job level.

In related work, Boschmans (2008) examines the effect of promotions on performance-pay contracts. In a three-period model, he focuses on a single firm with two job levels. He shows that since workers assigned to the higher job level have no further promotion opportunities, their wage contracts should be tied more directly to performance. The intuition behind this result is in line with the current model; old workers who have no promotion prospects are provided with incentives for effort only through bonus payments. However, his model does not address the issue of how the worker's career-concern incentives affect the size of bonus payments at different job levels and at various stages of the worker's career. Nor does he examine the interplay between the worker's incentives from bonus payments and her career-concern incentives. On the contrary, the current paper addresses both of these issues and provides empirical evidence for the model's predictions.

1.3 Model

In this section I develop a theoretical model that focuses on the worker's incentives in a corporate setting. I present the model in pieces. I first present the basic setup and the timing of the model. Next, I discuss the properties of the equilibrium I focus on. Then, starting with the last period, I present the optimal wage contract for each

period. I finish this section with a discussion of testable predictions derived from the model. All derivations and proofs are provided in the Appendix.

1.3.1 Basic Setup and Timing

I consider a three-period model with free entry and identical firms that produce output using labor as the only input. In each period labor supply is fixed at one unit for each worker whose career lasts three periods. Without loss of generality, each worker is referred to as young in period 1, middle-aged in period 2, and old in period 3. The worker's (innate) ability is denoted θ and distributed according to $F_\theta(\cdot)$ with support in $[\theta_L, \theta_H]$, $\theta_H > \theta_L$. None of the labor market participants including the worker himself observes the true value of θ , while its distribution is common knowledge. The asymmetric information structure of the model is built on how firms gradually learn about a worker's ability. The current employer privately observes the output realization of the worker at the end of each period, and uses that information to revise its beliefs regarding the worker's ability. It then uses the additional information when making a promotion decision. Potential employers, on the other hand, use the promotion decision as a signal of ability.

Each firm consists of three jobs denoted job 1 to job 3, and the worker can produce either high or low output in each job level. Let $y_j \in \{Y_L^j, Y_H^j\}$ be the output produced in job level j , $j = 1, 2, 3$, and $Y_H^j > Y_L^j$. If worker i is assigned to job j in

period t , the probability of producing the high level of output is given by

$$Pr(y_{ijt} = Y_H^j) = [e_{ijt}\theta_i], \quad (1.1)$$

where e_{ijt} is the effort exerted by worker i assigned to job j in period t .⁸ Note that using the multiplicative specification means that effort and ability are complements.⁹

Rosen (1982) illustrates that decisions of those in higher job levels are more vital to the organization since they have implications for the marginal productivity of workers in lower job levels, and consequently that returns to ability are convex. Therefore, poor performance of workers in higher positions reduces the firm's profits more severely. To incorporate this, I assume that $Y_L^j > Y_L^{j+1}$ for $j = 1, 2$. Further, I assume that $[Y_H^{j+1} - Y_L^{j+1}] > [Y_H^j - Y_L^j]$ for all j , so the impact of ability on the expected output increases with job level.¹⁰

If a worker is employed by the same firm in a subsequent period, she becomes more productive owing to her firm-specific human capital.¹¹ Accordingly, the worker produces $s_k y_j$ if she remains at her current employer, and produces $h y_j$ if she gets a new job in the market, where s (h) represents the accumulation of firm-specific (general) human capital, and k denotes the tenure at the current firm. I make the

⁸Since $Pr(y_{ijt} = Y_H^j) \in [0, 1]$, e_{ijt} is defined on the interval $[0, 1/\theta_H]$.

⁹The binary specification of output is not important for the results presented in the paper, and it is adopted for analytical tractability.

¹⁰One can generalize the model by assuming $Pr(y_{ijt} = Y_H^j) = c_j [e_{ijt}\theta_i]$. In that case, this assumption would be replaced by $c_{j+1}[Y_H^{j+1} - Y_L^{j+1}] > c_j[Y_H^j - Y_L^j]$ and $c_j > 0$ for all j . Note that the order of c_j 's could have an intuitive meaning; for example, assuming $c_3 > c_2 > c_1 > 0$ would imply that the impact of ability (or effort) on the probability of producing the high level of output increases with job level. Note that the current model normalizes c_j to 1 for all j .

¹¹Note that this is true even if the worker changes her job level at the same firm. Therefore, building up the firm-specific human capital is independent of job level.

assumption that $s_3 > s_2 > 1$, so that the worker's output increases with tenure at the firm, and that $s_k > h \geq 1$, so that the expression $s_k - h$ can be interpreted as the firm-specificity of human capital.¹² The worker could build up her firm-specific human capital either through learning-by-doing or through on-the-job training (OJT) provided by the firm. Since it is not the primary interest of the paper, the mechanism to build firm-specific human capital is not modeled.

I assume that employers cannot offer long-term contracts, i.e., they cannot commit to a specific wage profile or promotion decisions in subsequent periods. Also, potential employers do not observe bonuses. In order to draw out the implications of the interaction between the bonus contract and career-concern incentives that arise from the hierarchical structure of the firm, I also assume that output is contractible but not publicly observable.¹³ As a result, each period a single-period wage contract that consists of a base salary α and a bonus payment β , which is paid if the worker produces the high output in that period, is offered to workers. Therefore, a wage contract in period t takes the general form $w_{jt}(y_{jt}) = \alpha_{jt} + B_{jt}$, where $B_{jt} = \beta_{jt}$ if $y_{jt} = Y_H^j$, and zero otherwise. Note that given the binary output structure, this wage contract is efficient since it yields the first-best effort level.¹⁴

¹²Note that if $h = 1$, then none of the human capital the worker builds at the current firm is transferable to another firm in the market. Also, this specification implies that the worker does not accumulate general human capital over time. However, this assumption does not drive the results of the paper, and is used as a simplification.

¹³In other words, the employer can credibly reveal output to the court, but output is not observable by rival firms. Mukherjee (2008) and Koch and Peyrache (2009) make use of the same assumption to allow for output-contingent payments in the presence of career concerns.

¹⁴Note that the mechanism that allocates bonuses to workers does not allow any distortionary actions that could be taken by employees since it is assumed that the firm directly observes the output level produced by the worker, and decides if the worker merits the bonus, or not. Several authors discuss how a supervisor, whose responsibility includes assessing the worker performance, may

Assume that firms and workers are risk neutral, and that both of them have a discount rate of zero. Let the worker have the following utility function:

$$U(w_1, w_2, w_3; e_1, e_2, e_3) = \sum_{t=1}^3 [w_t - g(e_t)],$$

where w_t is the wage paid in period t and $g(e_t)$ is the disutility of exerting effort level e_t . I assume that function $g(\cdot)$ is strictly increasing and convex (i.e., $g' > 0$, $g'' > 0$) and $g(0) = 0$.

The structure of the game, similar to that in Ghosh and Waldman (2010), is as follows. In period one, all workers are *ex-ante* identical and assigned to job level 1 given a parameter restriction imposed below. After being assigned to job level 1, each worker chooses an effort level, which is privately known by the worker himself, and output is realized. The output realization y_{i1} , which is privately observed by the current employer and the worker, conveys some information about the worker's innate ability. Using that, the current employer updates its beliefs regarding the worker's ability and makes a promotion decision at the beginning of the second period. Potential employers, which do not have any information about the worker's ability, use the promotion decision made by the current firm as a signal of ability and make wage offers. Then, the current employer is allowed to make a counter-offer after observing the wage offers made by the potential employers. Finally, the worker chooses a firm for which to work in the second period after comparing the wage offers.

cause a misallocation of monetary rewards. For example, Milgrom and Roberts (1988), and Milgrom (1988) discuss how employees may indulge in influence activities to improve their performance reports; Prendergast and Topel (1996) suggest that supervisors may favor some workers purely for exogenous reasons; Fairburn and Malcomson (2001) discuss conditions under which employees may bribe the supervisor to earn the monetary reward contingent on the worker performance.

I assume when the current employer and the market make wage contracts that induce the same expected utility level, the worker remains with the current employer.¹⁵ The same sequence of events is repeated in the last period, and the worker retires at the end of period three.

1.3.2 Equilibrium

I focus on perfect Bayesian equilibria (PBE) of the model in which beliefs are derived from Bayes' rule given equilibrium strategies, and equilibrium strategies are optimal for employers and workers in each period of the game given beliefs. Note that assuming a binary output structure simplifies the analysis since it lets me focus on the role of promotions in providing incentives, in conjunction with bonus payments, rather than dealing with inefficiency results. When promotions serve as a signal of the worker's ability, there is an incentive to distort the promotion decision. However, this result is not relevant in the model proposed here for the following reason. That the output is a binary outcome indicates that workers who produced the same output are observationally the same to the current employer. Therefore, if promotion decisions are distorted, the equilibrium does not entail turnover within the firm. Since the focus of the paper is on incentive effects of job hierarchies and bonuses, I will consider parameterizations that allow job-to-job mobility within the firm, so that I can discuss how bonuses are aligned with incentives coming from the hierarchical structure of the firm. Note that this simplification, which is natural in

¹⁵This condition is equivalent to assuming an infinitesimal moving cost borne by the worker.

the current context, indicates that promotion decisions are efficient and they convey all private information the current employer has about the worker's ability.¹⁶

It is also worthwhile to highlight the role of firm-specific human capital on the equilibrium of the model. The fact that the worker becomes more productive over time at her current firm relative to other firms in the market increases the value of the worker to the current employer. However, the worker cannot benefit from that in terms of higher expected wages since her outside option, which is determined by her productivity in a competing firm, is not affected from her build-up of firm specific human capital.¹⁷ Therefore, the current employer earns positive rents from middle-aged and old workers. As a result, even though both the current employer and potential employers have the same information about the worker's ability in equilibrium, the current employer has incentives to retain the worker owing to the presence of the firm-specific human capital. Therefore, there is no turnover in equilibrium; workers are retained by their first period employers throughout their careers.

Starting with the last period, I solve the game backward. Subscript i will be omitted in the rest of this section.

¹⁶An implication of this result is that the equilibrium I focus on is not characterized by a winner's curse result in which potential employers are willing to offer the worker a wage contract which is consistent with the belief that the worker has the lowest productivity among workers with the same labor market signal (i.e., the same age and job assignment.).

¹⁷The extent to which the worker benefits from her firm-specific human capital in terms of higher wages depends on the degree of transferability of her human capital (measured by h). Accordingly, as the transferability of human capital increases (i.e., as h increases), the worker receives higher wage offers from the competing firms.

The Third Period

In the beginning of the third period, the current employer updates its beliefs regarding the worker's ability after observing her output in the second period. Therefore, the expected probability of a worker producing the high level of output in the last period if assigned to job j is given by $p_j^e(y_1, y_2) = e_j \theta_3^e(y_1, y_2)$, where $\theta_3^e(y_1, y_2) = E[\theta|y_1, y_2]$.¹⁸ The current employer's optimization problem which is to find the optimal contract for this period is given by

$$\max_{\alpha_{j3}, \beta_{j3}} s_3 [p_j^e(y_1, y_2) [Y_H^j - Y_L^j] + Y_L^j] - p_j^e(y_1, y_2) \beta_{j3} - \alpha_{j3}$$

subject to

$$e_j \epsilon \arg \max_{\hat{e}_j \in [e_L, e_H]} \alpha_{j3} + p_j^e(y_1, y_2, \hat{e}_j) \beta_{j3} - g(\hat{e}_j), \quad (1.2)$$

$$\alpha_{j3} + p_j^e(y_1, y_2) \beta_{j3} - g(e_j) \geq \bar{U}_3(y_1, y_2), \quad (1.3)$$

where (1.2) is the incentive constraint, and (1.3) is the participation constraint. Note that (1.3) implies that the optimal contract must give the worker at least her reservation utility, which is determined by the potential employers' demand for the same worker. Since the output realizations of the worker are private information for the current employer, the worker's outside option depends on the signals that potential employers receive regarding the worker's ability level. As promotions that serve as a signal of ability are determined by the worker's output realizations, the outside option can be represented as a function of the worker's output history (y_1, y_2) .

¹⁸Note that I suppress the e_j 's in the notation for $p_j^e(\cdot)$ for the sake of expositional clarity.

One can show that the optimal wage contract and the effort level induced by the contract satisfies¹⁹

$$\beta_{j3} = s_3[Y_H^j - Y_L^j], \quad (1.4)$$

$$\alpha_{j3} = \bar{U}_3(y_1, y_2) - [p_j^e(y_1, y_2, e_j^*)s_3[Y_H^j - Y_L^j] - g(e_j^*)], \quad (1.5)$$

$$g'(e_j^*) = \theta_3^e(y_1, y_2)s_3[Y_H^j - Y_L^j]. \quad (1.6)$$

As (1.4) indicates, the bonus payment in the last period is equal to the extra output produced by the worker, thus it increases with job level.²⁰ Since the worker's only incentive to exert effort in the last period is provided by the bonus payment, as indicated by (1.6), workers at higher job levels exert more effort in this period. Another implication of (1.6) is that the optimal effort level is increasing in the worker's expected ability level. As will be shown, workers at higher job levels are of higher ability in equilibrium, thus they exert more effort not only because their rewards are greater but the marginal probability of earning them are also greater. Finally, note that bonus contracts are the same for workers in the same job level, yet their realized bonuses will differ since not all workers earn bonuses that they are eligible for. Expected wages of workers at the same job level, on the other hand, differ if they have different output histories. Output realizations determine promotions which, in turn, are signals sent to the market. Therefore, the labor market has a more positive perception about the abilities of promoted workers than those of non-promoted

¹⁹As I explain in the Appendix, I employ the first-order approach to solve for the optimal contract (Rogerson, 1985).

²⁰Bonuses take this simple form because the output has a binary structure and effort level is a continuous variable. The employer sets the bonus payment equal to the additional output the worker can produce, and lets the worker choose her effort level to equate the marginal cost of effort to the expected marginal return.

workers. As a result, promoted workers have higher reservation utilities since their outside options are relatively better.

The Second Period

At the end of the first period, the current employer privately observes what level of output the worker produced and updates its beliefs regarding the worker's ability to $\theta_2^e(y_1) = E[\theta|y_1]$. Using that additional information regarding workers' ability level, it then makes a promotion decision for each worker. To do that, the current employer solves for the optimal contract that will be offered to each middle-aged worker depending on their first period output realizations y_1 .

In solving for the optimal contract, the current employer maximizes its expected profits from retaining the worker. Therefore, it takes expected profits both in the second and third periods into account when choosing the optimal wage contract. Similarly, the worker is concerned about her expected utility levels both in the second and third periods when choosing what level of effort to put forth. Therefore, introducing some notation is necessary to formulate the problem properly. Let $\pi_3^e(y_1, y_2)$ denote the expected profits of the current employer in the third period from retaining a worker with output history (y_1, y_2) , and $\bar{U}_3(y_1, y_2)$ denote the same worker's reservation utility in the third period. Finally, let $p_j^e(y_1) = e_j \theta_2^e(y_1)$ be the expected probability of the worker producing the high level of output in job level j . Then, the optimal contract for each job level can be found by solving the following optimization

problem:

$$\max_{\alpha_{j2}, \beta_{j2}} s_2 [p_j^e(y_1)[Y_H^j - Y_L^j] + Y_L^j] - p_j^e(y_1)\beta_{j2} - \alpha_{j2} + p_j^e(y_1)\pi_3^e(y_1, y_H) + [1 - p_j^e(y_1)]\pi_3^e(y_1, y_L)$$

subject to

$$e_j \in \arg \max_{\hat{e}_j \in \{e_L, e_H\}} \alpha_{j2} + p_j^e(y_1, \hat{e}_j)\beta_{j2} - g(\hat{e}_j) + p_j^e(y_1, \hat{e}_j)\bar{U}_3(y_1, y_H) + [1 - p_j^e(y_1, \hat{e}_j)]\bar{U}_3(y_1, y_L) \quad (1.7)$$

$$\alpha_{j2} + p_j^e(y_1)\beta_{j2} - g(e_j) + p_j^e(y_1)\bar{U}_3(y_1, y_H) + [1 - p_j^e(y_1)]\bar{U}_3(y_1, y_L) \geq \bar{U}_2(y_1), \quad (1.8)$$

where (1.7) is the incentive constraint, and (1.8) is the participation constraint.

Using the first-order conditions of this problem, one obtains

$$\beta_{j2} = s_2 [Y_H^j - Y_L^j] + [\pi_3^e(y_1, y_H) - \pi_3^e(y_1, y_L)] \quad (1.9)$$

$$\alpha_{j2} = \bar{U}_2(y_1) - [p_j^e(y_1)\beta_{j2} + p_j^e(y_1)\bar{U}_3(y_1, y_H) + [1 - p_j^e(y_1)]\bar{U}_3(y_1, y_L) - g(e_j^*)] \quad (1.10)$$

$$g'(e_j^*) = \theta_2^e(y_1)[\beta_{j2} + [\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)]] \quad (1.11)$$

Unlike old workers, middle-aged workers have both explicit and implicit incentives to exert effort this period. As (1.11) indicates, the explicit incentives come from the bonus payment, β_{j2} , which the worker earns if she produces high output this period. In addition, the fact that the worker enjoys a higher utility level last period if she produces high output this period, as indicated by the term $[\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)]$, generates implicit incentives for the worker.

Note that the worker who produced the high level of output this period enjoys a higher utility level in the last period, regardless of the current employer's promotion

decision. If the worker is promoted to a higher job level after producing the high level of output, potential employers updating their beliefs about the worker's ability level make higher wage offers that could give the worker higher expected utility. This part of the argument is simple. However, the same worker attains a higher expected utility even if she is not given a promotion by her current employer. To illustrate this, consider two middle-aged workers of whom only one produced the high level of output. When neither of these two workers is promoted, potential employers have no information to differentiate between the two. As a result, they will offer the same wage contract, i.e., the same base salary and bonus, to these workers. However, both the current employer and workers observe what level of output is produced by each worker, and update their beliefs accordingly. Thus, the current employer believes that the successful worker is more likely to produce high output in the last period. As a result, the expected utility from the wage contract offered by potential employers will be higher for the successful worker even though the other worker is made the same offer. Hence, as the reservation utility of the successful worker is greater, she attains a higher utility level.

Rewriting (1.9) more explicitly makes it easier to interpret bonus payments and relate them to career concerns.

$$\beta_{j2} = s_2[Y_H^j - Y_L^j] + s_3[E[Y|y_1, y_H] - E[Y|y_1, y_L]] - [\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)] - \Lambda, \quad (1.12)$$

where $\Lambda = [g(e_{l,3}^*) - g(e_{m,3}^*)]$ and $l(m)$ is the worker's job level in period three if she produced high (low) level of output in the second period, that is, if $y_2 = y_H$ ($y_2 = y_L$). The first term in (1.12) is the additional output the worker can produce this period

if the worker succeeds and the second term is the additional rents the employer can extract next period given that the worker produced high output this period. The third term in (1.12) reflects the career concerns; it implies that the optimal bonus contracts are adjusted to embody career-concern incentives by imposing a lower bonus payment than there would be if there were no career concerns. The last term, Λ , reflects the disutility of being in a higher job level in the last period. Since the worker exerts higher effort at higher job levels, the worker incurs a higher disutility of effort if she ends up working in a higher job level in the last period.

The First Period:

As all workers are *ex-ante* identical at the beginning of this period, the probability of a worker producing the high level of output, $p_1^e = e_1 E[\theta]$, is public information. To decrease the number of cases to be considered, I assume that on average young workers are more productive in job level 1.²¹ Therefore, they are assigned to job level 1 at the beginning of their careers. As firms with symmetric information about workers' abilities compete in the market for young workers, these workers are paid their expected output in the current period plus the expected surplus they generate in subsequent periods. Consequently, the employer earns zero profits from the hire, i.e., the zero profit condition holds.

²¹That is, $Y_L^1 + e_1^* E\theta[Y_H^1 - Y_L^1] > Y_L^j + e_j^* E\theta[Y_H^j - Y_L^j]$ for $j = 2, 3$.

The following problem characterizes the optimal wage contract for the first period.

$$\max_{\alpha_1, \beta_1} \alpha_1 + p_1^e \beta_1 - g(e_1) + p_1^e \bar{U}_2(y_H) + [1 - p_1^e] \bar{U}_2(y_L)$$

subject to

$$e_1 \in \arg \max_{\hat{e}_1 \in [e_L, e_H]} \alpha_1 + p_1^e(\hat{e}_1) \beta_1 - g(\hat{e}_1) + p_1^e(\hat{e}_1) \bar{U}_2(y_H) + [1 - p_1^e(\hat{e}_1)] \bar{U}_2(y_L) \quad (1.13)$$

$$p_1^e [Y_H^1 - Y_L^1] + Y_L^1 - [\alpha_1 + p_1^e \beta_1] + p_1^e \pi_2^e(y_H) + [1 - p_1^e] \pi_2^e(y_L) \geq 0, \quad (1.14)$$

where $\pi_2^e(y_1)$ is the expected profits made by the current employer in the second period if the worker produces y_1 in the first period, and $\bar{U}_2(y_1)$ is the same worker's reservation utility in the second period. At this point, firms offer wage contracts that maximize the worker's expected lifetime utility subject to the incentive compatibility constraint (1.13), and zero-profit condition (1.14).

Note that the expected profits next period, $\pi_2^e(y_1)$, implicitly includes the expected profits in the last period. Therefore, (1.14) ensures that the expected profits from hiring a young worker generates non-negative profits to the firm. Since that constraint is binding at the optimum, firms make zero expected profits from hiring a young worker. Note that (1.13) ensures that the worker's optimal effort choice maximizes her lifetime expected utility. Therefore, similar to middle-aged workers, young workers also have incentives to produce the high level of output to enjoy higher utility levels in subsequent periods.

The optimal wage contract for young workers is characterized by (1.15) through (1.17).

$$\beta_1 = [Y_H^1 - Y_L^1] + [\pi_2^e(y_H) - \pi_2^e(y_L)] \quad (1.15)$$

$$\alpha_1 = Y_L^1 + \pi_2^e(y_L) \tag{1.16}$$

$$g'(e_1^*) = E[\theta][\beta_1 + [\bar{U}_2(y_H) - \bar{U}_2(y_L)]] \tag{1.17}$$

Similar to the second-period problem, (1.17) indicates that the worker has explicit incentives from bonus payments and implicit incentives due to career concerns. The optimal base salary and bonus payment in the first period are easy to interpret: the firm pays the worker the sum of the low level of output that can be produced this period and the expected lowest profits made in the second period as a base salary. The bonus payment, on the other hand, consists of the additional output when high output is produced in the first period plus the additional rent the worker can generate in the second period.

1.3.3 Analysis and Testable Implications

In order to derive testable implications, my discussion focuses on parameterizations for which in equilibrium there are strictly positive probabilities a worker remains at her period-1 employer and earns a promotion in each period. Since the output has a binary structure, these conditions indicate that the equilibrium entails realistic results in which the worker is promoted to the next job level when she produces the high level of output, and the current employer always has incentives to match the outside wage offers to retain its employee. Also, parametric restrictions ensure that the worker who produced the low level of output is not assigned to a lower job level,

that is, she is not demoted.²²

As indicated, it is efficient to assign all young workers to job 1. Since all employers have exactly the same information about young workers' ability and there is free entry to the market, the labor market for young workers mimics a perfectly competitive market in the sense that employers make zero expected profits from hiring a young worker. Consequently, all young workers, independent of their ability, earn higher expected wages than their expected productivity.

Beginning with the second period, workers follow different career paths with diverse earnings profiles. Specifically, young workers who produce the high level of output earn the bonus they are eligible for, and they are promoted to job level 2 in the beginning of the second period. Young workers who produce the low level of output, on the other hand, do not earn the bonus, and they remain at job level 1. The following proposition formally states this result.

Proposition 1 *The equilibrium behavior in the second period is as follows:*

1. *All middle-aged workers remain at their period-1 employers.*
2. *The middle-aged worker who produced Y_H in the first period is promoted to job level 2 at which she becomes eligible for the bonus equal to $\beta_{22} = s_2[Y_H^2 - Y_L^2] + [\pi_3^e(y_H, y_H) - \pi_3^e(y_H, y_L)]$, and attains the expected utility $\bar{U}_2(y_H)$.*
3. *The middle-aged worker who produced Y_L in the first period is kept on job level*

²²Specific parametric restrictions that ensure these conditions are provided in the Appendix.

1. In that case, she becomes eligible for the bonus equal to $\beta_{12} = s_2[Y_H^1 - Y_L^1] + [\pi_3^e(y_L, y_H) - \pi_3^e(y_L, y_L)]$, and her expected utility is given by $\bar{U}_2(y_L)$.

Promotion decisions for old workers are similar to those for middle-aged workers. Accordingly, middle-aged workers who produce the high level of output receive the bonus, and they are promoted to the next job level in the last period, whereas their counterparts who produce the low level of output do not receive the bonus and remain at their current job level.

Proposition 2 *The equilibrium behavior in the last period is as follows:*

1. *Regardless of promotion decisions, all old workers remain at their period-1 employers.*
2. *The old worker who produced Y_H at job level 2 in the second period is promoted to job level 3 at which she becomes eligible for the bonus equal to $\beta_{33} = s_3[Y_H^3 - Y_L^3]$ and attains $\bar{U}_2(y_H, y_H)$.*
3. *The old worker who produced Y_L at job level 2 in the second period is kept on the same job level. In that case, the worker becomes eligible for the bonus equal to $\beta_{23} = s_3[Y_H^2 - Y_L^2]$ and attains $\bar{U}_2(y_H, y_L)$ in the last period.*
4. *The old worker who produced Y_H at job level 1 in the second period is promoted to job level 2 at which she becomes eligible for the bonus equal to $\beta_{13} = s_3[Y_H^2 - Y_L^2]$ and attains $\bar{U}_2(y_L, y_H)$.*

5. *The old worker who produced Y_L at job level 1 in the second period is kept on the same job level. In that case, she becomes eligible for the bonus equal to $\beta_{13} = s_3[Y_H^1 - Y_L^1]$ and attains $\bar{U}_2(y_L, y_L)$.*

As the discussion so far should have made clear, the main goal of the current model is to examine how bonuses are aligned with other forms of incentives provided to the worker. The employer's main intention in using bonus contracts is to implement the efficient level of effort. In doing that, the employer takes the worker's career-concern incentives into account as setting the optimal size of bonus payments. That is to say, the size of bonus payments is determined in accordance with the total incentives required to induce the efficient level of effort and the career-concern incentives of the worker. As the employer needs to offer higher bonuses to implement a higher level of effort, an increase in the efficient level of effort leads to an increase in the size of bonus payments. On the other hand, the size of bonus payments is negatively related to the size of the worker's career-concern incentives. That is, the employer offers lower bonuses to workers whose career-concern incentives are stronger, and vice versa.

Overall, the interaction between the two mechanisms, which are efficient levels of effort and career-concern incentives, determine the size of bonus payments. As both levels of efficient effort and career-concern incentives depend on the worker's job level and age, comparison of bonus payments across job levels and age groups provides the first two testable predictions of the model.

Corollary 1 *Holding the worker's age constant, the size of bonus payments increases with job level. That is, $\beta_{22} > \beta_{12}$ and $\beta_{33} > \beta_{23} > \beta_{13}$.*

This prediction states that the size of bonus payments increases with job level both for middle-aged and old workers. To see the intuition behind this, consider two middle-aged workers at job levels 1 and 2. The efficient level of effort is higher at job level 2 since returns to ability are greater at the same job level. Hence, other things equal, the worker at job level 2 is offered a higher bonus contract than the worker at job level 1. However, the career-concern incentives of the worker at job level 2 are also higher.²³ Therefore, incorporating the career-concern incentives reduces the size of bonus payments of the worker at job level 2 relatively more. The juxtaposition of these two opposite effects reveals that the former dominates the latter, thus the worker at job level 2 is eligible to earn higher bonuses than the worker at job level 1 is. This follows from the fact that the worker's expected net surplus is convex with respect to her expected ability. In other words, the worker at job level 2 is expected produce a greater surplus both in the current period and the next period since her expected ability is higher than the worker at job level 1.

Since this result holds despite the fact that the worker at job level 2 has stronger career-concern incentives than the worker at job level 1, it may seem inconsistent with the argument proposed by Gibbons and Murphy (1992). They show that the optimal contract implies that the explicit incentives must be weaker for workers with

²³As the model indicates, the reward for promotion increases with job level. Therefore, the worker at job level 2 enjoys higher benefits than the worker at job level 1 if she earns a promotion. This disparity in rewards for promotion implies that the worker at job level 2 has higher career-concern incentives than her counterpart at job level 1.

stronger career-concern incentives. Yet, their argument assumes that the comparison is made by holding the efficient level of effort the same across workers, which is not the case in the current model. As higher job levels that entail greater returns to ability are occupied by high-ability workers, the efficient level of effort increases with job level. Therefore, the worker at the higher job level is offered larger bonuses even though she also has stronger career-concern incentives.

Note that the mechanism driving the result differs for middle-aged and old workers. That is, bonuses for middle-aged workers are adjusted to embody career concern incentives, so higher bonuses reflect the disparity both in career concern incentives and returns to ability. Old workers, on the other hand, do not have career-concern incentives since they retire at the end of the current period. Therefore, their bonus payments, which are solely determined by the efficient level of effort, also increase with job level.

The second prediction of the model, which is formally stated in Corollary 2, illustrates how the size of bonus payments at a given job level changes with the worker's age. Particularly, it indicates that among workers at the same job level older ones are offered higher bonus contracts. The intuition for this result is similar to that found in Gibbons and Murphy (1992): since the worker has weaker career-concern incentives when she is closer to retirement, the employer needs to provide her with stronger explicit incentives by offering higher bonuses.

Corollary 2 *For a given job level j , the size of bonus payments increases with the worker's age, that is, $\beta_{j3} > \beta_{j2}$ for $j = 1, 2$.*

As should be clear from the discussion thus far, the worker is provided with explicit incentives through bonuses and career-concern incentives through promotions. In order to generate a testable prediction that addresses the relation between the two forms of incentives, I conduct a comparative-statics analysis with respect to the parameter h . Note that as h increases, the firm-specificity of human capital decreases, that is, the worker can transfer more of her human capital built at the current firm to competing firms in the market. In other words, the worker becomes more productive at competing firms as h increases.

As discussed earlier, the period-1 employer earns zero expected rents from hiring a young worker. Due to the presence of firm-specific human capital, however, the period-1 employer earns positive rents from employment in subsequent periods. The worker becomes more productive over time at her current firm by building up firm-specific human capital. Yet, as wage contracts offered by potential employers reflect the worker's productivity at rival firms, they do not capture the increase in the worker's productivity due to her firm-specific human capital. Consequently, the current employer earns positive rents from its middle-aged and old employees. Note that the size of economic rents the current employer earns from employment depends on the degree of the firm-specificity of human capital. Specifically, the current employer earns higher rents if the firm-specificity of human capital is smaller.

An increase in the parameter h has two ramifications. First, the worker's outside option increases since potential employers offer wage contracts that reflect the worker's productivity at competing firms. As outside wage offers increase more at

higher job levels (due to the convexity result shown in the Appendix), the gain in the expected utility from winning a promotion increases.²⁴ In other words, the worker is entitled to earn a higher reward for her good performance in the current period. Hence, a decrease in the firm-specificity of human capital results in an increase in the worker's career-concern incentives. Second, the current employer offers lower bonus contracts. This follows since the bonus contract for the middle-aged worker is adjusted to embody career-concern incentives. As the worker's career-concern incentives increase, the employer offers lower bonuses since a part of the required incentives to induce the efficient level of effort is provided by the higher career-concern incentives. The following corollary formally states this result.

Corollary 3 *For a middle-aged worker, an increase in h (i.e., an increase in general and decrease in the firm-specificity of human capital) leads to an increase in the gain in the expected utility from winning a promotion and a decrease in the size of bonus payments the worker earns in the current period. That is, an increase (decrease) in $[\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)]$ leads to a decrease (increase) in β_{j2} .*

The result implies that the bonus payment, which gives the worker explicit incentives to perform better, is negatively related to the implicit incentives provided through the possibility of promotions. As discussed earlier, a worker who is promoted to the next job level experiences a large increase in her expected utility for the next

²⁴The gain in expected utility upon good performance (i.e., $\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)$) is defined as the difference between the expected utility of the old worker if she produces the high level of output in the second period and her expected utility if she produces the low level of output in the same period. In other words, it is the prize for a promotion (similar to the one defined by Lazear and Rosen (1981)) expressed in expected utility terms.

period. Therefore, the possibility of earning a promotion gives implicit incentives to the worker to put forth more effort. Another crucial point in this exercise is that the decrease in the firm-specificity of human capital does not change the efficient level of effort since the total incentives provided to the worker remains the same. Yet, it alters the composition of incentives offered to the worker by lowering the bonus contract and increasing the prize for promotions.

Now let us turn to competing theories that also predict that bonuses increase with job level. Using the idea of career concerns, Gibbons and Murphy (1992) show that bonuses should increase with age since workers close to retirement have weaker career concern incentives, and the optimal contract balances the explicit incentives coming from bonuses and the implicit incentives arising from the worker's career concerns. Applying this idea to internal labor markets, one can show that bonuses increase with job level because workers at higher job levels are older on average, thus they need to be provided higher bonuses to compensate for their diminished career-concern incentives. The model presented in this paper, however, yields a distinguishing prediction that bonuses increase with job level even if age is held constant.

The second potential explanation makes use of the argument that performance pay increases with job level because returns to effort are greater at higher job levels. This result is derived from the employer's profit maximization problem; when returns to effort are higher, the employer offers higher performance pay in order to implement the efficient level of effort. Using this reasoning, Lemieux, MacLeod, and Parent

(2009) build a theoretical model in which performance pay increases with returns to effort and examine how the prevalence of performance pay in high-paying jobs contributes to earnings inequality.

Their argument implies that workers at the same job level should be eligible for bonuses of the same size since returns to effort are the same. However, the model I develop in the paper predicts that the age of the worker has a significant effect on bonuses since the employer takes the worker's career-concern incentives into consideration when setting the bonus contract. In particular, among workers at the same job level, younger ones have stronger career concern incentives. Therefore, the employer uses lower bonuses to elicit the efficient level of effort from young workers.

The predictions that will be tested in the next section can be summarized as follows: i) Controlling for the worker's age, the size of bonus payments increases with job level; ii) controlling for job level, the size of bonus payments increases with the worker's age; and iii) controlling for the worker's performance, the size of bonus payments in the current period is negatively related to the size of promotion prizes.

Before turning to the empirical analysis of these testable predictions, let me discuss how the theoretical results regarding the optimal wage contracts would be affected if the standard tournament approach were used to model promotions. Recall that in the standard tournament approach, the employer has the ability to commit to promotion prizes. On the other hand, the approach employed in the present paper, which is called the market-based tournament approach, implies that the employer cannot commit to promotion prizes because they are determined by labor market

demand. Now, assume the employer has the ability to commit to promotion prizes in the current setup. In that case, the employer could implement efficient levels of effort by choosing the same base salaries and bonus payments as those discussed above. However, that equilibrium would not be unique since the firm could choose any combination of base salaries and bonus payments that induce the same level of expected utility.

Note that one of these equilibria is such that bonus payments are set to zero for young and middle-aged workers. In that case, the worker's only incentives would come from promotion prizes as in Lazear and Rosen (1981). The reasoning behind this result is that since the employer can commit to promotion prizes, it is able to provide workers with incentives for effort only through the possibility of promotions instead of balancing between the incentives from bonus payments and promotions. However, this result does not apply to old workers for whom only bonuses can provide incentives for effort since they retire at the end of the current period. Overall, the equilibrium obtained via the market-based approach is unique and it yields positive bonus payments for each worker. Also note that the same equilibrium is one of many equilibria when commitment is possible.

1.4 Data

The data used in the empirical analysis come from the personnel records during the period 1969-1988 for all managerial employees of a medium-sized U.S. firm operating

in the financial-services industry. The data were first analyzed in the canonical studies of Baker, Gibbs and Holmstrom (hereafter called BGH) (1994a,b) on the internal labor markets. I assume the following restrictions for my working sample. First, since promotion dynamics for female workers may be different than they are for male workers (e.g., Milgrom and Oster, 1987; Lazear and Rosen, 1990), and there are few female workers in higher job levels, I restrict my analysis to male workers.²⁵ Second, as the bonus data cover only the period 1981-1988, I use observations from the earlier years only to construct lagged values of some variables. Third, since all compensation data are in local currencies, I only look at workers employed at plants in the U.S.

The data include salary, bonus and performance measure variables, as well as demographics including age, race, gender and education. Among these, variables of special interest are job levels, bonuses and performance ratings. Since the HR department of this firm does not provide any information about job levels, BGH (1994a) use movements between job titles to identify job levels.²⁶ In their original work, they identify 8 levels, where level 8 is the top level filled by the CEO. Since the dynamics that determine the CEO's compensation is different and there are fewer employees at higher levels due to the pyramidal structure of the firm, I drop observations in level 8, and combine levels 6 and 7 with level 5.²⁷

All compensation variables are reported annually, and measured in real terms in

²⁵In order to check the robustness of the results, I used the full sample to test the predictions of the model. Regression results were very similar to the results reported in the paper.

²⁶Some studies in the job ladder literature use pay variables to identify job levels (Lazear, 1992).

²⁷Gibbs (1995) uses the same breakout of job levels in his regressions.

1988 dollars. Bonuses for a given year are paid in February of the following year, and not all eligible employees earn bonuses (about 35.2 percent of all employee-years of data includes positive bonuses). Note that in addition to employee-years with positive bonuses, the data also include observations in which the worker is not eligible for bonuses, and those in which the worker is eligible but does not earn any bonuses. Subjective performance ratings are measured on a five-point scale, where 1 reflects the best performance. One caveat about performance ratings is that they are not available for all employee-years (69.8 percent of the sample includes performance ratings), thus the sample size gets smaller when they are included in the regressions. However, I will make use of performance ratings as a proxy for the worker's performance in a given year.²⁸

Summary statistics are reported in Table 1.1. The average worker is 40.5 years old and has a tenure of 6.4 years at the firm. Looking at the statistics by job level, one can see that the worker gets older, has longer tenure at the firm, receives better performance ratings and earns higher bonuses as she moves up the hierarchy. As there are fewer slots at the upper levels of the corporate hierarchy, the percentage of promotions decreases with job level.

²⁸Gibbs (1995) uses performance ratings in his analyses, and shows that they are correlated with promotions and bonuses. Also, Kahn and Lange (2010) and DeVaro and Waldman (2012) use them as a proxy for performance.

Table 1.1: Summary Statistics (Standard Errors in Brackets)

Level	N	Earned bonus	Bonus payment	Salary	Promoted	Age	Tenure		Rating available	
							at current level	at firm		
1	1,438	0.177 [0.382]	3,029.5 [3,935.0]	37,836.7 [9,942.1]	0.247 [0.431]	36.7 [9.5]	2.6 [2.3]	2.7 [2.3]	2.2 [0.8]	0.635 [0.482]
2	1,673	0.248 [0.432]	3,981.9 [4,007.0]	43,348.3 [9,127.1]	0.171 [0.376]	39.2 [9.1]	3.3 [2.8]	5.3 [3.3]	2.2 [0.7]	0.748 [0.434]
3	1,913	0.398 [0.490]	4,975.8 [4,873.9]	52,258.7 [9,607.9]	0.109 [0.311]	40.1 [8.9]	3.6 [2.9]	6.7 [3.8]	1.9 [0.7]	0.724 [0.447]
4	1,593	0.457 [0.498]	11,881.9 [13,939.3]	79,61.36 [19,783.0]	0.013 [0.112]	42.6 [8.0]	5 [3.6]	8.7 [4.2]	1.7 [0.7]	0.709 [0.454]
5	192	0.403 [0.491]	48,847.2 [32,240.8]	152,328.6 [57,026.5]	0.05 [0.218]	46.6 [7.2]	4.5 [3.7]	9.6 [4.8]	1.7 [0.7]	0.404 [0.491]
All	6,809	0.352 [0.478]	9,608.7 [15,099.3]	61,117.1 [30,553.4]	0.109 [0.312]	40.5 [9.0]	3.9 [3.2]	6.4 [4.2]	1.9 [0.7]	0.698 [0.459]

1.5 Empirical Analysis

The empirical analysis consists of three sections. In the first section, I examine the firm's policy on bonuses. In particular, I scrutinize which observable attributes of workers are related to the firm's decision to offer bonus contracts, and how these attributes are related to a worker's probability of earning bonuses. In the second section, I test the predictions of the theoretical model concerning the effects of the worker's age and job level on bonus payments. In the last section, I test the model's prediction regarding the trade-off between incentives provided through bonus payments and incentives provided through promotions.

1.5.1 Firm's Policy on Bonuses

As should be clear from the discussion of the empirical predictions, the variable of primary interest is the size of bonus payments. In other words, the theory built in this paper focuses on bonuses which are actually paid to the worker rather than bonuses which the worker is eligible to earn. Therefore, consistent with the model I use the subsample of bonus recipients to test the empirical predictions. That is, the sample that I use to test the predictions excludes observations (i.e., employee-years of data) in which the worker was either not eligible to earn bonuses or she was eligible but did not earn any bonuses. Unfortunately, we do not have any information on what basis the firm decides to offer bonus contracts to its employees. However, to help illuminate the firm's policy on bonuses I begin my empirical analysis by considering

the firm's decisions to offer bonus contracts and to reward bonuses, respectively.

Even though examining the firm's contract choice is beyond the scope of this paper, I evaluate some conjectures borrowed from the related literature. Presumably, the firm may use job characteristics to decide whether to offer a bonus contract to a worker. For example, workers assigned to jobs with a better monitoring technology (i.e, lower monitoring costs, lower measurement errors and so on) may be more likely to be offered bonus contracts (Lazear, 1986). One implication of this reasoning is that workers at higher job levels in which output is more sensitive to effort and ability are more likely to get bonus contracts (Lemieux, MacLeod, and Parent, 2009). Alternatively, the firm may be inclined to offer bonus contracts to older workers whose career-concern incentives are weaker (Gibbons and Murphy, 1992).

To investigate these possibilities, I estimate logit models predicting whether or not a worker is eligible to earn a bonus in a given year. Results are reported in Table 1.2.²⁹ The baseline specification reported in column (1) includes job level dummies and age terms in addition to control variables for race, education and year. The results indicate that workers at higher job levels are more likely to be offered bonus contracts. These results also indicate that age has a statistically significant positive effect on the probability of being eligible to earn a bonus. Thus, consistent with our conjecture, older workers are more likely to be offered bonus contracts. Column (2) augments the baseline specification with a binary variable that indicates whether performance ratings are available for a given employee-year of data. Interestingly, the

²⁹Throughout the paper, statistical significance at the 5%, and 1% levels is denoted by *, and **, respectively. Also, \overline{age} refers to the age of the average worker in the whole sample.

Table 1.2: Determinants of the Probability of the Firm Offering a Bonus Contract

Variables	A.Pooled Logit			B.Fixed-Effects Logit		
	(1)	(2)	(3)	(4)	(5)	(6)
Level=2	0.251** [0.0449]	0.187** [0.0476]	0.189** [0.0481]	-0.0228 [0.0679]	0.0201 [0.0689]	0.0853 [0.0737]
Level=3	0.584** [0.0443]	0.492** [0.0467]	0.486** [0.0474]	0.288** [0.0953]	0.357** [0.0970]	0.481** [0.111]
Level=4	1.383** [0.0465]	1.298** [0.0491]	1.272** [0.0497]	1.637** [0.148]	1.722** [0.151]	1.933** [0.176]
Level=5	1.254** [0.0748]	0.842** [0.0864]	0.869** [0.0871]	3.349** [0.342]	3.392** [0.352]	3.621** [0.371]
Age	0.0968** [0.0135]	0.114** [0.0141]	0.0571** [0.0148]	1.018** [0.0449]	1.069** [0.0463]	0.991** [0.0522]
Age ² /100	-0.123** [0.0158]	-0.143** [0.0164]	-0.0924** [0.0170]	-0.618** [0.0472]	-0.646** [0.0484]	-0.563** [0.0522]
Rating available		-1.630** [0.0424]	-1.712** [0.0422]		-0.487** [0.0367]	-0.539** [0.0374]
Tenure at level=2			0.560** [0.0419]			0.444** [0.0484]
Tenure at level=3			0.566** [0.0472]			0.412** [0.0612]
Tenure at level=4			0.576** [0.0538]			0.142 [0.0728]
Tenure at level \geq 5			0.753** [0.0462]			0.173* [0.0806]
N(worker-yrs)	40,808	40,808	40,808	30,405	30,405	30,405
N(workers)	7,203	7,203	7,203	3,563	3,563	3,563
Log-likelihood	-16943	-15850	-15680	-8106	-8015	-7959
Pseudo-R ²	0.386	0.425	0.432	0.435	0.441	0.445
χ^2 -test $H_0: \delta^j = 0$ for all j	1168	998.3	935.8	220.8	219.3	209.7
p-value	0.000	0.000	0.000	0.000	0.000	0.000
χ^2 -test $H_0: \gamma_1 +$ $\overline{age} * \gamma_2 / 50 = 0$	2.124	0.529	60.16	2567	2549	1414
p-value	0.145	0.467	0.000	0.000	0.000	0.000

point estimate for this variable is negative and statistically significant at the 1 percent level. Therefore, the firm is less likely to offer bonus contracts when performance ratings are available. One potential explanation for this finding is that the firm uses both bonuses and performance ratings to provide workers with feedback about their current performance. Thus, the firm substitutes performance ratings with bonuses for some employee-years. However, since there is no information regarding why performance ratings are not available for some observations, there is no way to test this conjecture.

To analyze the effect of future promotions, I estimate the specification reported in column (3) which includes binary variables indicating the worker's tenure at the current job level. Since workers who remain at the same job level longer are less likely to get promoted, tenure at the current job level may pick up the effect of future promotions (Gibbs, 1995). The results suggest a monotonic relationship between tenure at the current job level and the probability of being eligible for bonuses. Hence, workers who are less likely to get promoted are more likely to be offered bonus contracts. The model developed in the paper offers a theoretical explanation for this empirical pattern. As indicated in the discussion of the third prediction, the model predicts that the employer offers wage contracts that balance the worker's incentives provided through bonuses and her career-concern incentives provided through promotions. That is, the employer increases the size of bonus payments when the worker's career-concern incentives get lower. Even though it is not formally shown in the paper, it is possible to generalize this argument to shed light on the firm's contract choice. Since workers whose promotion prospects are limited have weaker

career-concern incentives, the firm needs to provide them with additional incentives for effort. As a result, the firm is more likely to offer bonus contracts to these workers in order to elicit efficient levels of effort.

Finally, to examine if the findings are robust to unobserved worker heterogeneity, I re-estimate the same specifications using the fixed-effects logit model (see columns (4) to (6)).³⁰ The results are qualitatively the same as those in pooled logits, except for tenure at current job levels. The monotonic relationship between the probability of offering a bonus contract and the tenure at current job level does not hold for tenure longer than 4 years. However, workers are more likely to get a bonus contract in any year of their tenure than their first year at the current job level.

The theoretical model developed in the previous section implies that the probability of earning a bonus increases with the worker's effort and ability. As I demonstrated, the employer elicits the efficient level of effort which increases with job level. Therefore, we expect that, other things equal, the probability of earning a bonus increases with job level. As discussed before, I make use of performance ratings as a proxy for performance. In addition, I use average salary increase and tenure at the current job level as proxies for expected ability.³¹ The rationale for using these variables to control for the worker's expected ability is as follows. BGH (1994a,b)

³⁰I estimate the fixed-effects logit models using the conditional maximum likelihood approach (Chamberlain, 1984). Note that this estimator does not treat worker-specific fixed effects as parameters to be estimated along with other parameters which are actually estimated. Also, estimation of the fixed-effects logit model relies on workers whose eligibility status changes over time (eligible to non-eligible or vice versa). Therefore, workers whose eligibility status do not change during the sampling period are not used in the estimation.

³¹Gibbs (1995) uses these variables in logit models predicting promotions and finds that they are correlated with promotions.

find that workers who experience faster wage growth are more likely to be promoted, thus they are also of higher expected ability. Gibbs (1995) argues that the firm uses promotion decisions to sort workers, so that workers who remained longer at a given job level are expected to be of lower ability. Note that both the average salary increase and tenure at the current job level are expected to be positively related to the worker's probability of earning a bonus.

To investigate the firm's decision to reward bonuses, I estimate logit models predicting whether or not the worker earns a bonus in a given year. Results are reported in Table 1.3. The first specification reported in column (1) includes dummy variables for job levels and performance ratings in addition to control variables for age, race, education and year. The results show that workers at higher job levels are more likely to earn bonuses than workers at lower job levels. Point estimates for performance ratings have the expected signs and they are statistically significant at the one percent level.³² Accordingly, the probability of earning a bonus increases monotonically with performance. Indeed, the findings regarding job levels and performance ratings are consistent in all estimated specifications reported in Table 1.3. Consistent with our hypothesis, the average salary increase at the current job level has a statistically significant positive effect on the probability of earning a bonus (see column (2)). The results also show that workers are more likely to earn a bonus in their second to fourth years than their first year at the current job level. However, the relationship is not statistically significant for tenure longer than five years (see column (3)). The

³²Note that the omitted category for performance ratings is 1, which reflects the best performance level. Therefore, we expect negative point estimates for performance rating dummies.

Table 1.3: Determinants of the Probability of Earning a Bonus

Variables	A.Pooled Logit			B.Fixed-Effects Logit		
	(1)	(2)	(3)	(4)	(5)	(6)
Level=2	0.559** [0.0858]	0.558** [0.0890]	0.563** [0.0856]	0.942** [0.128]	1.102** [0.143]	0.756** [0.131]
Level=3	1.200** [0.0809]	1.180** [0.0843]	1.205** [0.0808]	1.710** [0.149]	1.949** [0.167]	1.321** [0.161]
Level=4	1.521** [0.0854]	1.514** [0.0887]	1.541** [0.0859]	1.918** [0.190]	2.382** [0.209]	1.265** [0.218]
Level=5	1.812** [0.141]	1.821** [0.147]	1.811** [0.141]	2.722** [0.315]	3.390** [0.340]	1.523** [0.372]
Rating=2	-0.670** [0.0459]	-0.611** [0.0482]	-0.682** [0.0463]	-0.465** [0.0581]	-0.422** [0.0596]	-0.466** [0.0584]
Rating=3	-1.806** [0.0762]	-1.705** [0.0796]	-1.818** [0.0770]	-1.358** [0.0977]	-1.298** [0.0992]	-1.343** [0.0986]
Rating=4	-2.453** [0.303]	-2.282** [0.304]	-2.447** [0.304]	-1.922** [0.390]	-1.833** [0.392]	-1.929** [0.390]
Av salary increase at current level		2.586** [0.539]			8.039** [0.907]	
Tenure at level=2			0.221** [0.0627]			0.0634 [0.0675]
Tenure at level=3			0.152* [0.0713]			-0.0976 [0.0818]
Tenure at level=4			0.165* [0.0810]			-0.284** [0.0964]
Tenure at level \geq 5			-0.0427 [0.0686]			-0.607** [0.112]
N(worker-yrs)	27,466	26,103	27,466	13,329	13,026	13,329
N(workers)	6,018	5,260	6,018	1,918	1,853	1,918
Log-likelihood	-7315	-6914	-7302	-4085	-3916	-4061
Pseudo-R ²	0.353	0.362	0.354	0.18	0.195	0.184
χ^2 -test $H_0: \delta^j = 0$ for all j	429.3	391.3	432	139.3	153.2	78.26
p-value	0.000	0.000	0.000	0.000	0.000	0.000

fixed-effects logits which are reported in columns (4) to (6) yield similar findings except for tenure at current level. Specifically, the results indicate that workers with tenure more than 4 years are less likely to earn a bonus than workers who are in their first years at the current level (see column (6)).

1.5.2 Effect of Job Levels and Age on Bonuses

This section analyzes the empirical predictions of the current model regarding the effect of job levels and the worker's age on bonus payments. Recall that the two predictions to be tested are whether the size of bonus payments increases with job level after controlling for the worker's age (captured in Corollary 1), and whether the size of bonus payments increases with the worker's age after controlling for job level (captured in Corollary 2).

Before testing the predictions formally, I look at the basic data on bonuses categorized by job level. As seen in Table 1.1, the average bonus payment increases with job level. Indeed, it has a convex structure since the increase is larger at higher job levels. Similarly, the variation in bonus payments also increases with job level. Therefore, a first glance at the data reveals that bonus payments increase with job level. It is the task of the econometric analysis to examine to what extent this relationship persists after conditioning on related control variables.

To empirically test the predictions, I specify a model describing determinants of

bonus payments as follows.³³

$$\log\beta_{it} = Z_i\varphi + X_{it}\tau + a_{it}\gamma + \sum_{j=2}^5 L_{it}^j\delta^j + t_i + \mu_i + \epsilon_{it}, \quad (1.18)$$

where $\log\beta_{it}$ is the logarithm of bonus payment made to worker i at year t ; Z_i is a vector of time-invariant attributes of worker i which includes indicator variables for education and race; 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 heterogeneity in worker productivity; a_{it} is a vector that includes the age of worker i at year t and its squared term (divided by 100 for convenience); L_{it}^j is a level-specific binary indicator ($j = 2, 3, 4, 5$) which is specified as $L_{it}^j = 1$ if $L_{it} = j$ and 0 otherwise, where L_{it} refers to the job level of worker i at year t ;³⁴ t_i is a vector of year dummies which is used to control for the effect of the business cycles on bonus payments; μ_i is a worker-specific unobserved factor, which may be correlated with other explanatory variables in the model;³⁵ ϵ_{it} is an idiosyncratic shock term, independently and identically distributed with a mean of zero.³⁶

The crucial point in testing the effect of job levels on bonuses is workers' assignment to job levels. As the theoretical model illustrates, more able workers are assigned to higher job levels in equilibrium. Even though proxies for performance

³³Smeets and Warzynski (2008) estimate a similar specification to examine how the span of control affects the size of bonus payments. The major difference between their specification and equation (1.18) is that the former includes proxies for the span of control, whereas the latter includes controls for performance ratings and tenure at current job level as well as worker fixed-effects.

³⁴Note that Level 1 is the omitted category in this specification.

³⁵I 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 context.

³⁶In fixed-effects estimations, I allow correlation across time, and thus report the standard errors that account for any correlation within i .

and ability are included in regressions, a part of the variation that affects job assignment is 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. To this end, I begin the analysis with the ordinary least squares (OLS) estimation on pooled data. As 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 I make use of the panel dimension of the data via the fixed effects (FE) estimation, which relaxes conditions required by the OLS estimation.³⁷

First, I examine how much of the variation in bonus payments is explained by the variation in job levels and age terms. To this end, I estimate simple regressions in which job level indicators and age are only independent variables. Results are reported in Table 1.4. Consistent with some previous studies (e.g., Leonard, 1990; Ortin-Angel and Salas-Fumas, 2002), job levels turn out to be a very important determinant of compensation. As seen in column (1), the 50.4 percent of the cross-sectional variation in bonuses is explained by job levels. The explanatory power of age terms is relatively much smaller; they explain only the 5.8 percent of the variation (see column (2)). When I include both job level dummies and age terms (see column (3)), the variation explained by the model increases very slightly (R^2

³⁷Technically, the OLS estimation yields unbiased estimates if ability differences that affect workers' assignment to job levels are fully accounted by variables used in this specification, i.e., $E[L_{it}^j \cdot \eta_{it} | Z_i, X_{it}, a_{it}, t_i] = 0$ for all t and j , where $\eta_{it} = \mu_i + \epsilon_{it}$. The FE 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 $E[L_{it}^j \cdot \epsilon_{it} | Z_i, X_{it}, a_{it}, t_i, \mu_i] = 0$ for all t and j .

Table 1.4: Variation in Bonus Payments Explained by Job Levels and Age

Variables	A.Pooled OLS			B.Fixed-Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Level=2	0.343** [0.0354]		0.336** [0.0357]	0.420** [0.0869]		0.292** [0.0869]
Level=3	0.584** [0.0321]		0.576** [0.0330]	0.587** [0.0976]		0.307** [0.104]
Level=4	1.318** [0.0312]		1.311** [0.0330]	0.848** [0.108]		0.416** [0.120]
Level=5	2.821** [0.0471]		2.830** [0.0490]	1.352** [0.167]		0.836** [0.162]
Age		0.149** [0.0108]	0.0272** [0.00812]		0.340** [0.0397]	0.280** [0.0405]
Age ² /100		-0.155** [0.0127]	-0.0356** [0.00953]		-0.336** [0.0453]	-0.284** [0.0448]
N(worker-yrs)	5,856	5,856	5,856	5,856	5,856	5,856
N(workers)	2,547	2,547	2,547	2,547	2,547	2,547
Log-likelihood	-5442	-7325	-5431	-870.1	-805.2	-731.3
Adjusted R ²	0.504	0.058	0.506	0.816	0.82	0.824
F-test $H_0: \delta^j = 0$ for all j	1491		1330	21.33		7.961
p-value	0.000		0.000	0.000		0.000
F-test $H_0: \gamma_1 +$ $\overline{age} * \gamma_2 / 50 = 0$		307.19	2.14		84.51	34.9
p-value		0.000	0.1432		0.000	0.000

increases by 0.002.). Therefore, one can conclude that the cross-sectional variation in bonus payments are largely explained by job levels, while age terms have minor explanatory power. The FE estimation results are also provided in the same table to investigate how much of the within variation is explained by the within variation in job levels and age terms. Accordingly, both job levels and age terms individually explain approximately 82 percent of the within variation in bonus payments (see columns (4) and (5)). Similar to the pooled regressions, using both of them increases

Table 1.5: Determinants of Bonuses

Variables	A.Pooled OLS			B.Fixed-Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Level=2	0.338** [0.0404]	0.347** [0.0448]	0.357** [0.0442]	0.299** [0.0629]	0.159* [0.0652]	0.222** [0.0719]
Level=3	0.579** [0.0394]	0.599** [0.0429]	0.591** [0.0421]	0.322** [0.0762]	0.138 [0.0757]	0.267** [0.102]
Level=4	1.230** [0.0427]	1.180** [0.0459]	1.148** [0.0449]	0.436** [0.0887]	0.214* [0.0922]	0.431** [0.146]
Level=5	2.671** [0.0595]	2.539** [0.0695]	2.589** [0.0674]	0.804** [0.118]	0.600** [0.193]	0.858** [0.234]
Age	0.0268** [0.00881]	0.0189* [0.00939]	-0.00739 [0.00943]	0.263** [0.0297]	0.279** [0.0405]	0.194** [0.0482]
Age ² /100	-0.0327** [0.0103]	-0.0232* [0.0107]	-0.00298 [0.0107]	-0.293** [0.0330]	-0.242** [0.0435]	-0.164** [0.0481]
Ratings	No	Yes	Yes	No	Yes	Yes
Tenure at level	No	No	Yes	No	No	Yes
N(worker-yrs)	5,856	3,948	3,948	5,856	3,948	3,948
N(workers)	2,547	2,104	2,104	2,547	2,104	2,104
Log-likelihood	-5208	-3380	-3282	-625.5	567.4	584.7
Adjusted R ²	0.541	0.525	0.548	0.83	0.862	0.863
F-test $H_0: \delta^j = 0$ for all j	875.9	522.5	546.1	13.54	3.681	4.897
p-value	0.000	0.000	0.000	0.000	0.005	0.000
F-test $H_0: \gamma_1 +$ $\overline{age} * \gamma_2 / 50 = 0$	0.136	0.0111	42.89	15.08	17.66	6.555
p-value	0.712	0.916	0.000	0.000	0.000	0.011

the explanatory power of the model marginally (see column (6)).

Table 1.5 displays the results of estimating equation (1.18) for alternative specifications. Panel A presents the pooled regression results, while Panel B presents the FE regression results for the same specifications. Control variables for race, education, and year are included in all pooled regressions, while only year dummies are

common to all FE regressions. Recall that the first prediction states that holding age constant, bonus payments increase with job level, that is, $\delta^{j+1} > \delta^j > 0$ for $j = 1, 2, 3, 4$.

The results provide clear support for the first prediction: Point estimates for job level dummies are significantly different from zero at the 1 percent level in a two tailed test, and they are increasing with job level. Results in column (1), which serve as a benchmark, indicate that bonuses increase sharply as one moves up the hierarchy. The point estimates suggest that, other things equal, bonuses earned by workers at level 2 are 0.33 percentage points higher than bonuses earned by workers at level 1. The differential increases dramatically at higher levels; bonuses earned by workers at level 5 are 2.67 percentage points higher than that earned by workers at level 1. In column (2), I control for the worker's performance in the current period by including dummies for performance ratings. The point estimates for job levels slightly increase for levels 2 and 3, whereas they slightly decrease at levels 4 and 5.³⁸ I further include dummies for tenure at current job level in column (3). The results are very close to those in columns (1) and (2). For example, the bonus differential between level 1 and level 2 is 0.35 percentage points, while it is 2.58 percentage points between level 1 and level 5.

Results from the FE regressions indicate that unobserved worker heterogeneity

³⁸As mentioned earlier, performance ratings are not available for all employee-years of data. Therefore, the number of observations decreases from 5,856 to 3,948 in specifications that include performance ratings. As a robustness check, I estimated the baseline specifications, reported in column (1) and column (4) using the subsample of observations in which performance ratings are available. Results were very similar to those reported in the paper.

plays an important role in workers' assignments to job levels. This follows since the point estimates fall sharply, especially at higher job levels, when we include worker-fixed effects. Therefore, using the FE regressions to test the first two predictions is more appropriate since the pooled regressions yield biased point estimates for job levels.

The FE regressions results also provide supporting evidence for the first prediction. The baseline specification in column (4) indicates that a worker at level 1 earns 0.29 percentage points higher bonuses when she is promoted to Level 2, and that the premium increases to 0.80 percentage points at level 5. Once I control for the worker's performance, the differential in bonus payments decreases in all levels. As seen in column (5), a worker earns 0.15 percentage points higher bonuses if she is promoted from level 1 to level 2, while the differential between the entry level and the top level is 0.60 percentage points. Interestingly, when I include tenure at the current job level, point estimates for job level dummies increase (see column (6)). For example, the differential between the top level and the entry level turns out to be 0.85 percentage points, which is higher than the differential reported in columns (4) and (5).

I now turn to the second prediction which implies that bonus payments increase with age after controlling for job level. Since both age and its squared term enter the estimating equation in which the dependent variable is the log of bonus payments, the effect of age on bonus payments is measured by the semi-elasticity of bonus payment with respect to age. This elasticity term is given by $\gamma_1 + a\tilde{g}e(1/50)\gamma_2$, where $a\tilde{g}e$ is

the age level at which the elasticity is evaluated.³⁹ The bottom panel of Table 1.5 displays 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. In addition, Figure 1.1 plots the the age semi-elasticity of bonus payment for point estimates from pooled and FE regressions.

The pooled regressions yield results that are inconsistent with the prediction. As seen in Table 1.5, point estimates from columns (1) and (2) indicate that null hypothesis that the age semi-elasticity of bonus payment evaluated at the average worker is zero cannot be rejected. In column (3), the F-test indicates that the semi-elasticity is statistically different from zero (p-value is practically zero). However, as seen in Figure 2 the semi-elasticity calculated using point estimates from this specification is negative for all age levels, and very close to zero. Hence, even though the F-test indicates a statistically significant negative effect, it is economically not significant.

Results from the FE regressions provide clear support for the second prediction. As seen in columns (4) to (6) in Table 1.5, the point estimates for age terms have the expected signs, and the semi-elasticity evaluated at the average worker is positive and statistically significant at the 1 percent level in all specifications. Moreover, the effect of age on bonus payments is economically significant. For example, the results from column (4) indicate that an additional year for a 40-year-old worker leads to a 2.9

³⁹Using equation (1.18), one can show that the semi-elasticity of bonus payments with respect to age is given by $\frac{\partial E[\log\beta_{it}|L_{it}^j, a_{it}, Z_i, X_{it}, t_i]/\partial a_{it}}{E[\log\beta_{it}|L_{it}^j, a_{it}, Z_i, X_{it}, t_i]} = \gamma_1 + age(1/50)\gamma_2$, where *age* is the level of age at which the elasticity is evaluated.

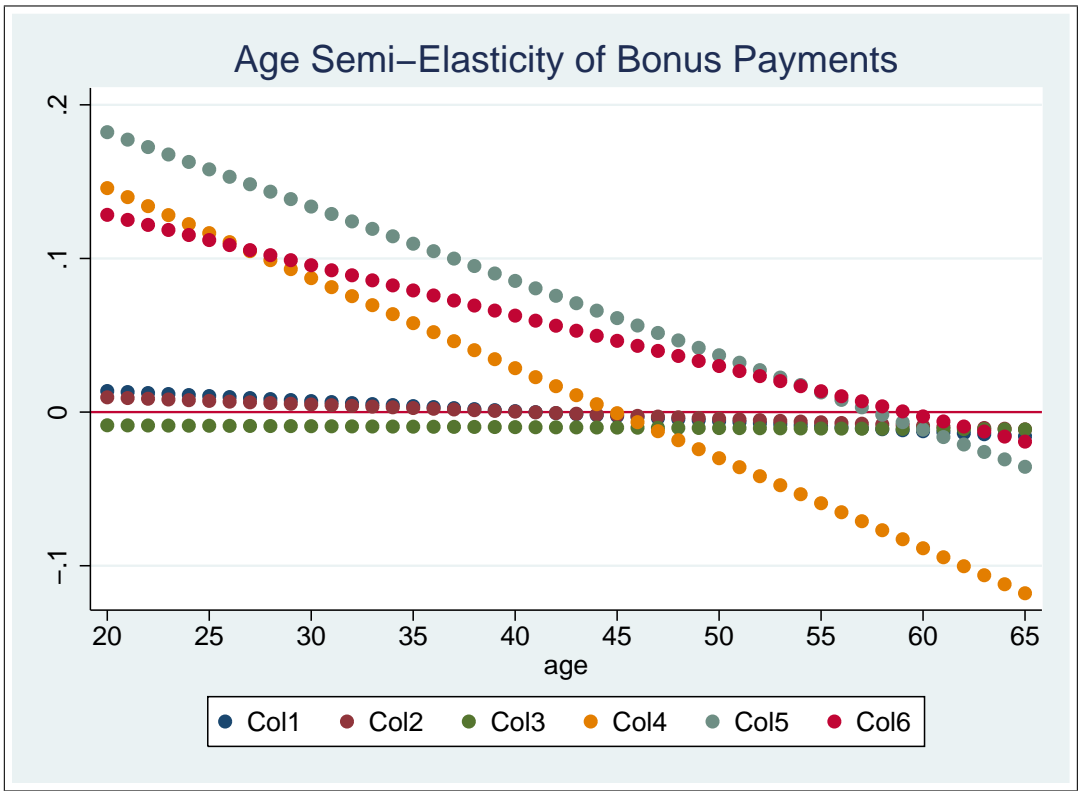


Figure 1.1: Age Semi-Elasticity of Bonus Payments

percent increase in bonus payments. The increase goes up to 8.5 percent in column 5 in which workers' performance are controlled for via performance ratings. When I further control for tenure at the current job level in column 6, the elasticity term decreases slightly; an additional year for a 40-year-old worker brings a 6.3 percent increase in bonus payments.

As shown in Figure 1.1, the semi-elasticity decreases with age and converges to zero when the worker's age is about 59 (it approaches to zero at the age of 45 in the baseline specification reported in column 4). In order to determine at what age the effect becomes statistically insignificant, I calculate the semi-elasticity for ages

between 20 and 60 and corresponding standard errors for point estimates from the FE regressions. Results are reported in Table 1.6. One observes that the effect is significant for a range of age values. For example, the effect is statistically significant and positive until the age of 51 according to the specification in column (5), while it becomes insignificant at the age of 48 according to point estimates from column (6).

The declining pattern of age elasticities is interesting, and seems inconsistent with the theory developed in this paper. However, I believe it is possible to reconcile the theory with this empirical finding. One potential reason for why we observe a declining effect of age on bonus payments beyond a certain age is that compensation packages may include pecuniary benefits, other than salaries and bonuses, such as stock options. Stock options are mostly common in higher job levels and among older workers. Hence, a generalization of the theory developed in the paper can explain why the effect of age on bonus payments decreases with age. If older workers own more stock options than younger workers, it means that a smaller part of the total incentives required to elicit the efficient level of effort needs to be provided by bonuses. In other words, the optimal contract balances the worker's incentives by reducing bonuses when incentives either from career-concerns or stock options increase. As a result, we observe a declining effect of age on bonus payments. Unfortunately, the dataset used in the empirical analysis does not include information about stock options. Therefore, testing this extension of the theory is not feasible with this dataset.

Table 1.6: Semi-Elasticity of Bonus Payments with respect to Age

Age	Semi-Elasticities from (4)		Semi-Elasticities from (5)		Semi-Elasticities from (6)	
26	0.111	[0.014]	0.153	[0.024]	0.109	[0.029]
27	0.105	[0.013]	0.148	[0.023]	0.106	[0.029]
28	0.099	[0.012]	0.143	[0.023]	0.103	[0.028]
29	0.093	[0.012]	0.139	[0.022]	0.099	[0.028]
30	0.087	[0.011]	0.134	[0.022]	0.096	[0.027]
31	0.081	[0.011]	0.129	[0.022]	0.093	[0.027]
32	0.076	[0.010]	0.124	[0.021]	0.09	[0.027]
33	0.07	[0.010]	0.119	[0.021]	0.086	[0.026]
34	0.064	[0.009]	0.114	[0.021]	0.083	[0.026]
35	0.058	[0.009]	0.11	[0.020]	0.08	[0.026]
36	0.052	[0.008]	0.105	[0.020]	0.077	[0.025]
37	0.046	[0.008]	0.1	[0.020]	0.073	[0.025]
38	0.04	[0.008]	0.095	[0.020]	0.07	[0.025]
39	0.035	[0.007]	0.09	[0.020]	0.067	[0.025]
40	0.029	[0.007]	0.085	[0.020]	0.063	[0.024]
41	0.023	[0.007]	0.081	[0.020]	0.06	[0.024]
42	0.017	[0.007]	0.076	[0.020]	0.057	[0.024]
43	0.011	[0.006]	0.071	[0.020]	0.054	[0.024]
44	0.005	[0.006]	0.066	[0.020]	0.05	[0.024]
45	-0.001	[0.006]	0.061	[0.020]	0.047	[0.024]
46	-0.007	[0.007]	0.056	[0.021]	0.044	[0.024]
47	-0.012	[0.007]	0.052	[0.021]	0.041	[0.024]
48	-0.018	[0.007]	0.047	[0.021]	0.037	[0.025]
49	-0.024	[0.007]	0.042	[0.021]	0.034	[0.025]
50	-0.03	[0.008]	0.037	[0.022]	0.031	[0.025]
51	-0.036	[0.008]	0.032	[0.022]	0.027	[0.025]
52	-0.042	[0.008]	0.027	[0.022]	0.024	[0.026]
53	-0.048	[0.009]	0.023	[0.023]	0.021	[0.026]
54	-0.054	[0.009]	0.018	[0.023]	0.018	[0.026]
55	-0.059	[0.010]	0.013	[0.024]	0.014	[0.027]
56	-0.065	[0.010]	0.008	[0.024]	0.011	[0.027]
57	-0.071	[0.011]	0.003	[0.025]	0.008	[0.028]
58	-0.077	[0.011]	-0.002	[0.025]	0.005	[0.028]
59	-0.083	[0.012]	-0.006	[0.026]	0.001	[0.028]
60	-0.089	[0.012]	-0.011	[0.026]	-0.002	[0.029]

1.5.3 Trade-off Between Bonus Payments and Career-Concern Incentives

The third prediction indicates that there is a trade-off between explicit incentives provided through bonus payments and implicit incentives provided through promotions (captured in Corollary 3). Recall that since workers experience a large increase in their expected utilities upon being promoted, the probability of winning a promotion provides them with incentives to exert effort. The prize for a promotion, which is given by $\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)$ in the theoretical model, is the difference between the worker's expected utility in the next period if she is promoted and her expected utility in the next period if she is not promoted. Borrowing the terminology of Lazear and Rosen (1981), let me call the prize for a promotion the spread in the rest of the section. In order to test the prediction that the size of bonus payments is negatively related to the spread, I first need to determine the empirical counterpart of the spread.

The obvious candidate to measure the worker's expected utility is her expected total compensation, which is the sum of salaries and bonus payments. As I discussed earlier, however, workers do not earn bonuses in every period in which they are eligible for bonuses. Hence, predicting the total compensation has some drawbacks since bonus payments are erratic. To address this issue, I will use salaries as a second proxy for the worker's expected utility. In the rest of the discussion, I use the term *compensation* to refer to the worker's expected total compensation.⁴⁰

⁴⁰For brevity, the discussion of the econometric technique focuses only on the worker's compen-

Note that for workers who are not promoted in a given year we cannot observe what their compensation would be if they were promoted. Similarly, for workers who are promoted in a given year we cannot observe what their compensation would be in the absence of a promotion. Therefore, the second issue in testing the prediction is to derive the worker's counterfactual compensation.

Following the method DeVaro and Waldman (2012) suggest, I propose a three-step procedure to test the third prediction⁴¹. In the first step, I estimate the following equation for the subsample of observations in which promotion occurred:

$$\log C_{it+1}^p = \log \alpha_{it} \kappa_W + Y_{it}^p \kappa_Y + \psi_{it}, \quad (1.19)$$

where $\log C_{it+1}^p$ is the logarithm of next year's total compensation of worker i who is promoted at year t , α_{it} is the salary paid to worker i at year t , and Y_{it}^p is the vector of control variables for job levels, age, year, education, race, tenure at the firm, tenure at the current level and performance ratings. For each observation in which the worker was not promoted, I use the parameter estimates from equation (1.19) to derive her predicted compensation upon being promoted.

In the second step, I estimate the following equation for the subsample of observations in which promotion did not occur:

$$\log C_{it+1}^{np} = \log \alpha_{it} \lambda_W + Y_{it}^{np} \lambda_Y + \xi_{it}, \quad (1.20)$$

sation. However, it equally applies to the promotion prizes measured by salaries.

⁴¹In order to test the hypothesis that the wage increase due to promotion decreases with education, DeVaro and Waldman (2012) propose to construct the counterfactual wage increases for workers who were promoted. They argue that one way to do this is first to predict wage increases in the absence of promotions using observations in which promotions did not occur, and then use the parameter estimates from this regression to predict promoted workers' counterfactual wages in the absence of promotions.

where $\log C_{it+1}^{np}$ is the logarithm of next year's total compensation of worker i who is not promoted at year t . In equation (1.20), Y_{it}^{np} includes individual-specific fixed effects, which are omitted in Y_{it}^p , and all the control variables in Y_{it}^p except time-invariant variables (education and race).⁴² I use the parameter estimates from equation (1.20) to derive a predicted no-promotion compensation for each observation in which the worker was promoted. Using the predicted values from the first two steps, I generate the predicted spread for each observation:

$$\hat{\Delta}_{it} = \begin{cases} \log C_{it+1}^p - \log \hat{C}_{it+1}^{np}, & \text{if } \text{prom}_{it}=1 \\ \log \hat{C}_{it+1}^p - \log C_{it+1}^{np}, & \text{if } \text{prom}_{it}=0 \end{cases}$$

In the third step, I estimate the augmented version of equation (1.18) to test whether bonus payments are negatively related to the estimated spread:

$$\log b_{it} = \hat{\Delta}_{it}\rho + Z_i\varphi + X_{it}\tau + a_{it}\gamma + \sum_{j=2}^5 L_{it}^j \delta^j + \epsilon_{it}, \quad (1.21)$$

Note that the third testable prediction implies that $\hat{\rho} < 0$.

Since equation (1.21) includes a predicted variable, $\hat{\Delta}_{it}$, as an independent variable, I have to adjust standard errors to take into account the sampling variability of this term. Otherwise, conventional methods produce underestimated standard errors (Murphy and Topel, 1985). To obtain consistent standard errors, I implement a non-parametric bootstrap method which allows me to use the variation in the bootstrapped estimates of ρ to adjust the standard error estimated from the original

⁴²It was not feasible to include worker-fixed effects in (1.19) because our sample includes very few workers who have been promoted more than once inside the time period of the sample.

sample.⁴³

One caveat of using the aforementioned three-stage procedure to test the prediction is the endogeneity of promotions. Similar to the union membership problem, if earning a promotion is endogenous to the model, the predicted compensation values will be biased (Robinson, 1989). However, the major difference between earning a promotion and being a union member (or being in the treatment group) is that the selection criteria is known, at least to some extent, in the former case, whereas how workers decide about union membership is less clear.⁴⁴ Specifically, the employer makes promotion decisions based on the worker's performance and availability of slots, whereas the criteria of being a union member is less clear. Therefore, using detailed control variables for the worker's performance and dummies for job titles should address the endogeneity problem to some extent. To further address the problem, I will also estimate the same regressions for the subsample of workers who have been promoted at least once in their careers. This approach will let me control the selection bias to the extent that the unobservable effect on earning a promotion operates through a time-invariant worker effect.⁴⁵

⁴³The method I implement is very similar to the approach that is used to compute standard errors with multiple imputed data (Rubin, 1987), and it can be summarized as follows. Drawing independent random samples from the subsamples of promoted and non-promoted workers, respectively, I first generate 50 datasets in addition to the original one. Then, I estimate (1.21) for each bootstrap sample and save the results. The corrected standard error for $\hat{\rho}$ is given by the formula $\sqrt{s_{\rho}^2 + \sigma_{\rho}^2}$, where s_{ρ}^2 is the sample variance of $\hat{\rho}$ estimated from the original sample, and σ_{ρ}^2 is the variance of the point estimates across the bootstrap samples (i.e., it is computed as $var(\hat{\rho}_1, \dots, \hat{\rho}_{50})$).

⁴⁴Another difference is that the promotion decision is more centralized than the decision on union membership in the sense that the employer is the only decision maker in promotions while each worker is an individual decision maker in the union membership case.

⁴⁵The two approaches that allow the estimation of endogenous treatment effects are instrumental variables and control function procedures (see references in Robinson (1989)). To apply these techniques to our context, however, we need a variable that is correlated with the probability of

Table 1.7: The Trade-Off Between Bonus Payments and Promotion Prizes Measured by Total Compensation

Variables	(1)	(2)	(3)	(4)	(5)
Estimated promotion prize	-0.585**	-0.550**	-0.451**	-0.516**	-0.290*
	[0.138]	[0.137]	[0.137]	[0.137]	[0.134]
Corrected standard error	[0.195]	[0.195]	[0.194]	[0.198]	[0.194]
p-value with corrected std error	0.002	0.004	0.02	0.009	0.135
Performance ratings	No	Yes	No	No	Yes
Tenure at level	No	No	Yes	No	Yes
Av salary increase at current level	No	No	No	Yes	Yes
N(worker-yrs)	2,941	2,941	2,941	2,941	2,941
Adjusted R ²	0.486	0.491	0.506	0.49	0.52
Log-likelihood	-2527	-2513	-2468	-2516	-2423

Table 1.8: The Trade-Off Between Bonus Payments and Promotion Prizes Measured by Salary

Variables	(1)	(2)	(3)	(4)	(5)
Estimated promotion prize	-1.596**	-1.548**	-1.210**	-1.452**	-0.838**
	[0.219]	[0.217]	[0.221]	[0.220]	[0.218]
Corrected standard error	[0.307]	[0.304]	[0.318]	[0.313]	[0.327]
p-value with corrected std error	0.000	0.000	0.000	0.000	0.01
Performance ratings	No	Yes	No	No	Yes
Tenure at level	No	No	Yes	No	Yes
Av salary increase at current level	No	No	No	Yes	Yes
N(worker-yrs)	2,941	2,941	2,941	2,941	2,941
Adjusted R ²	0.495	0.5	0.51	0.497	0.522
Log-likelihood	-2502	-2488	-2456	-2496	-2417

Tables 1.7-1.8 and Tables 1.9-1.10 display the results of estimating equation (1.21) for the whole sample and the subsample of workers who have been promoted at least once, respectively. For each table, Part A reports the results in which the estimated promotion prize is in terms of the worker's total compensation, while Part B reports the same results in which the estimated promotion prize is in terms of the worker's salaries. To assess how correcting the standard errors affects the results, I report both the original and the corrected standard errors. Also, note that all specifications reported in these tables include controls for job level, age terms, year, education and race.

Confirming the point made by Murphy and Topel (1985), the original standard errors are considerably lower than the corrected standard errors. However, this affects the significance of point estimates only marginally except in column (3). Accordingly, point estimates for the spread are statistically significant at worst at the 2.1 percent level.

The results displayed in Table 1.7 support the hypothesis that bonus payments are negatively related to the promotion prizes. The baseline specification reported in column (1) indicates that a 10 percent increase in the estimated spread leads to a 5.8 percent decrease in bonus payments. When I control for the worker's performance using performance ratings in column (2), the point estimate for the estimated spread

earning a promotion, but uncorrelated with the compensation increase. Since both the probability of earning a promotion and the compensation increase are determined by the worker's performance, finding such an exclusion restriction is a hard task. One variable that would provide an exclusion restriction is the separation decision of a worker, which is correlated with the promotion probabilities of workers who may be promoted to this worker's slot, and uncorrelated with their compensation increase. Unfortunately, this information is not available in our dataset.

decreases slightly, but remains statistically significant (a 10 percent increase in the spread is associated with a 5.5 percent decrease in bonus payments.) In column (3) in which I use dummy variables for the worker's tenure at the current job level, the point estimate for the spread decreases even further. Specifically, a 10 percent increase in the spread leads to a 4.5 percent decrease in bonus payments. Column (4) includes the average salary increase at the current job level to control for the worker's ability. Point estimates are very close to those from column (2) and statistically significant at conventional levels, thus they provide clear support for the prediction. Finally, column (5) reports the results when all of the three control variables used in columns (2)-(4) are included in the regression at the same time. The two-sided p-value indicates that the estimated prize is statistically not significant. However, a one-sided hypothesis test indicates that the effect is negative and statistically significant at the 7 percent level.

As seen in Table 1.8, the negative relationship between bonus payments and the promotion prize is more evident when the latter is expressed in terms of salaries instead of total compensation. We see that the point estimate for the promotion prize is statistically significant and negative in all specifications, and the magnitudes are relatively higher (in absolute terms) than those in Table 1.7. For example, the baseline specification in column (1) indicates that a 10 percent increase in the estimated promotion prizes leads to a 15.9 percent decrease in bonus payments. Also, the effect remains statistically significant (at the 1 percent level) when we include all control variables in column (5); a 10 percent increase in the promotion prize leads to a 8.4 percent decrease in bonus payments.

Table 1.9: The Trade-Off Between Bonus Payments and Promotion Prizes Measured by Total Compensation

Variables	(1)	(2)	(3)	(4)	(5)
Estimated promotion prize	-0.529**	-0.491**	-0.407**	-0.445**	-0.235
	[0.158]	[0.157]	[0.157]	[0.156]	[0.152]
Corrected standard error	[0.214]	[0.213]	[0.210]	[0.212]	[0.208]
p-value with corrected std error	0.013	0.021	0.052	0.036	0.259
Performance ratings	No	Yes	No	No	Yes
Tenure at level	No	No	Yes	No	Yes
Av salary increase at current level	No	No	No	Yes	Yes
N(worker-yrs)	2,602	2,602	2,602	2,602	2,602
Adjusted R ²	0.479	0.487	0.501	0.487	0.523
Log-likelihood	-2153	-2133	-2094	-2133	-2033

Table 1.10: The Trade-Off Between Bonus Payments and Promotion Prizes Measured by Salary

Variables	(1)	(2)	(3)	(4)	(5)
Estimated promotion prize	-1.451**	-1.377**	-1.044**	-1.263**	-0.612**
	[0.238]	[0.235]	[0.237]	[0.235]	[0.229]
Corrected standard error	[0.296]	[0.292]	[0.297]	[0.303]	[0.309]
p-value with corrected std error	0.000	0.000	0.000	0.000	0.047
Performance ratings	No	Yes	No	No	Yes
Tenure at level	No	No	Yes	No	Yes
Av salary increase at current level	No	No	No	Yes	Yes
N(worker-yrs)	2,602	2,602	2,602	2,602	2,602
Adjusted R ²	0.487	0.494	0.505	0.493	0.525
Log-likelihood	-2133	-2113	-2086	-2117	-2030

As discussed above, Tables 1.9 and 1.10 report the results from estimating the same specifications using the subsample of workers who have been promoted at least once in their careers. Results are qualitatively the same as those reported in Tables 1.7 and 1.8. However, the magnitude of the negative effect is smaller when the sample is restricted. Overall, the prediction is supported by the data. We observe that the promotion prize, measured in terms of either total compensation or salaries, has a negative effect of bonus payments the worker earns in the current period. Also, the negative effect is more evident when the promotion prize is expressed in terms of salaries.

1.6 Conclusion

Bonus contracts are a widely used method to provide workers with incentives to exert high effort. Therefore, understanding how bonus contracts can be effectively used in a corporate hierarchy is important, and it is the main goal of this paper. In analyzing bonus contracts, the main perspective underscored here is that bonus contracts should be examined jointly with other forms of incentives provided to the worker. In doing that, the paper presents a theoretical model that focuses on the interaction between incentives provided through the bonus payments and career-concern incentives that arise from the market's gradual learning about the worker's ability level and the hierarchical structure of the firm.

The mechanics of the model provides a rationale for why bonuses increase with

job levels. Accordingly, the employer uses bonus contracts to implement the efficient level of effort and takes the worker's career-concern incentives into account when setting the size of the bonus payment. Hence, two counteracting mechanisms are identified that determine the size of bonus payments; efficient levels of effort and career-concern incentives. Specifically, the model indicates that the size of bonus payments increases with the efficient level of effort the employer aims to implement, and decreases with the size of career-concern incentives of the worker. The comparison of bonus payments across workers at different job levels and of different age groups provides two testable predictions of the model. In addition, the model yields a third testable prediction that directly focuses on the trade-off between the implicit and explicit incentives provided to the worker. Specifically, the model predicts that the size of bonus payments is negatively related to promotion prizes.

The empirical analysis of these predictions produces supporting evidence for the model. Note that the three testable predictions distinguish the theoretical model developed in the present study from the two competing theories that can also explain why bonuses are larger at higher job levels. Therefore, the supporting evidence for the current model implies that it better matches the data than the competing explanations in the literature.

Future work might involve testing the predictions using cross-firm data. This analysis will allow one to examine whether firms operating in different industries use similar policies on bonuses. Particularly, an analysis on non-profit firms might give interesting results since these organizations are subject to a 'nondistribution con-

straint' that prohibits distributing profits to its employees and owners (e.g., Glaeser and Shleifer, 2001). Moreover, the current model focuses on the equilibrium in which there is no turnover. However, it is plausible to think that the possibility of quits and layoffs affects the worker's incentives. Hence, a fruitful way to extend the theoretical model to capture the incentive effects of quits and layoffs.

CHAPTER 2
THE EFFECTS OF PAY ON TURNOVER

2.1 Introduction

Worker turnover has been one of the fundamental themes in labor economics since it is prevalent, especially among young workers, and has long-lasting effects on workers' lifetime earnings. In their influential study on the mobility of young men in the U.S., Topel and Ward (1992) find that two-thirds of workers either change jobs or become unemployed in their first year of employment. They also show that wage increases due to job changes constitute about one third of total wage growth in the first ten years of these workers' careers. Consistent with these findings, there is also a substantial amount of empirical evidence indicating wage effects of worker mobility (e.g., Bartel and Borjas, 1981; McLaughlin, 1991; Keith and McWilliams, 1995). Overall, the empirical evidence points out the importance of understanding the determinants of turnover. Consequently, a large empirical literature has investigated the correlates of turnover, which include, but are not limited to, job performance (Bishop, 1990), relative wages (Galizzi and Lang, 1998), on-the-job training (Krueger and Rouse, 1998), and job prospects (Munasinghe, 2005).

The present study aims to contribute to this literature by focusing on the components of the worker's compensation separately. Specifically, the goal of the study is to examine the effects of pay on turnover with a particular emphasis on bonus

payments. Wages, which are the center of attention in this literature, are measured by salaries, whereas bonus payments have received little attention. This paper attempts to fill this gap by documenting the effects of bonus payments on turnover, and comparing them with that of salaries. To motivate the testable predictions concerning the effect of pay variables on turnover, I employ the wealth maximization hypothesis within the job search framework. The essence of this hypothesis is that the worker makes a separation decision in each period so that he maximizes the expected present value of his lifetime earnings. Consequently, the hypothesis yields a general prediction that the probability of turnover decreases with the worker's expected future earnings at the same firm. To translate this general prediction into testable predictions regarding salaries and bonus payments, I first investigate how these pay variables relate to the worker's future compensation.

To the extent that pay variables are serially correlated over time (in terms of either levels or growth rates), the current values of pay variables can be associated with their future values. Note that the serial correlation in pay variables implies association with the worker's future compensation in two ways. First, the worker's salary and bonus payments change over time in the absence of promotions. Second, pay variables can be associated with future compensation through signaling future promotions. There is empirical evidence that supports the hypothesis that salaries can be used to predict promotions. For example, Baker, Gibbs, and Holmstrom (1994b) find that workers with higher wage growth in a given job level are more likely to be promoted. The empirical relationship between bonus payments and promotions, on the other hand, has not been studied. Therefore, I will first empirically examine to what extent

bonus payments are associated with future promotions before turning to the effects of bonuses on turnover, which is the main focus of the present study.

To investigate the two mechanisms that relate the current values of pay variables to the worker's future compensation, I first examine serial correlation in pay. Note that the serial correlation in salaries takes salary increases due to promotion into account. Therefore, a part of the correlation may be driven by salary increases upon promotions. However, this connection is weaker for bonus payments since the promoted worker becomes eligible to earn higher bonuses, yet he is not guaranteed to earn the bonuses. As will be shown, serial correlation in pay remains significant after controlling for the worker's observable characteristics including his job level and current performance. Next, I examine to what extent pay variables are related to the worker's probability of earning a promotion. Consistent with the literature, both the level and the growth rate of salary have positive effects on the probability of promotions. Moreover, the results indicate that both having earned a bonus in the current period and the size of the earned bonus (in the current as well as in the previous period) have positive effects on the worker's probability of earning a promotion. Overall, the empirical evidence suggests a link between the current values of pay variables and the worker's future compensation.

After establishing this link, I address three main issues in the empirical analysis. First, I investigate how the level and the growth rate of salary are related to turnover. Second, I examine whether bonus payments provide additional information in predicting turnover after controlling for the level and the growth rate of salary. Finally,

I examine the extent to which the estimated effect of total compensation on turnover differs from that of salaries.

The empirical analysis of this paper is based on national survey data and data coming from the personnel records of a medium-sized U.S. firm operating in the financial services industry. This firm-level dataset, which was first used by Baker, Gibbs and Holmstrom (1994a, b), includes detailed information about workers' salaries and bonus payments, as well as providing subjective performance ratings and hierarchical job levels. As will be discussed in detail, these features enable us to control for the worker's current performance and his promotion prospects. Despite its advantages, the firm-level data has a shortcoming in that one cannot distinguish worker-initiated separations (quits) from employer-initiated separations (layoffs). In order to examine if pay variables have different effects on quits and layoffs, and to address heterogeneity of firms concerning their personnel policies, I make use of a sample drawn from the Panel Study of Income Dynamics (PSID). This additional analysis provides complementary evidence to the analysis based on the firm-level data.

Consistent with the empirical literature, the results regarding the effect of salary levels on turnover are mixed. Specifically, the results from the firm-level analysis indicate that salary level has a positive effect on turnover, whereas the results from the PSID sample yield the opposite outcome. On the other hand, both sets of results indicate that the growth rate of salary has a negative effect on turnover. The fundamental results concerning the effect of salaries do not differ for quits and layoffs. In addition, the results indicate that bonus payments have significant effects on

turnover. In particular, the analysis based on the firm-level data indicates that having earned a bonus, as well as the size of the bonus, have negative effects on turnover. The analysis based on the PSID sample produces related results. It indicates that the negative effect of bonus payments are statistically significant for layoffs, whereas the results are inconclusive for quits. Finally, the results show that salaries and total compensation, both in terms of levels and growth rates, have similar qualitative effects on turnover. However, the estimated negative effects of salaries are larger, in absolute terms, than those of total compensation.

The pecuniary returns of the job are a major determinant of worker turnover. Therefore, it is crucial to make use of all information regarding the worker's compensation in analyzing turnover. For example, controlling for the worker's compensation is vital to obtain unbiased estimates in an empirical study that focuses on how non-pecuniary benefits of the current job affect turnover. If the worker's total compensation is not properly controlled for, the point estimates for non-pecuniary attributes of the job are likely to be biased. In that sense, the results of the paper suggest that using both the growth rate of salary and the size of bonus payments to measure the worker's compensation is a better empirical approach in analyzing turnover.

The remainder of the paper is organized as follows. Section 2 discusses related studies in the literature. Section 3 discusses the wealth maximization hypothesis and testable predictions concerning the effects of pay variables on turnover. Section 4 describes the datasets used in the empirical analysis, and formally introduces the

fixed-effects logit model that is employed to estimate the effects of pay variables on turnover. Section 5 discusses the results from the empirical analysis. Section 6 concludes the paper.

2.2 Related Work

In motivating the testable predictions concerning the effect of pay variables on turnover, I make use of the wealth maximization model within the job search framework.¹ The central prediction in this literature regarding the relationship between pay variables and turnover is that separations should decline as a function of the current wage level and not as a function of wage growth (e.g., Jovanovic, 1979; MacDonald, 1988).² However, there is empirical evidence inconsistent with this hypothesis. For example, Topel and Ward (1992) find that the initial wage has a significant positive effect on turnover after controlling for current wage, experience, and tenure. Clearly, if the current wage is fully informative about the value of the job, the initial wage is expected to have no significant effect on turnover. The job-search framework will be further discussed in the next section where I motivate the testable predictions concerning the effect of pay variables on turnover.

Munasinghe (2000) provides a theoretical explanation concerning why turnover depends on rates of wage growth, and claims that his argument can also solve the

¹See Rogerson, Shimer, and Wright (2005) for an extensive survey of the literature.

²The reason behind this result is that the current wage level possesses all information about the quality of the match between the firm and the worker.

‘puzzle’ that Topel and Ward (1992) documented. The main assumption in his model is that there is heterogeneity in within-job wage growth rates.³ In equilibrium, jobs with high growth rates offer the same wage level as jobs with low growth rates at the time of hiring. However, the value of jobs with high growth rates exceeds the value of jobs with low growth rates in subsequent periods. Therefore, jobs offering high growth rates are less likely to end since workers at both types of jobs draw wage offers from the same distribution.

Note that the job search framework does not yield direct testable predictions regarding bonus payments. However, as I will demonstrate in the next section, it is possible to make use of the link between the worker’s expected earnings at the same job and turnover (via the wealth maximization hypothesis) to examine the effects of bonus payments on turnover. In this sense, the approach adopted in the present study is closest in spirit to that of Galizzi and Lang (1998) and Munasinghe (2005). The essence of the empirical approach followed by Galizzi and Lang (1998) is to use wages of workers with similar observable attributes as a proxy for the worker’s expected future wages. Consistent with the wealth maximization hypothesis, their empirical analysis indicates that the probability of quits decreases with expected future wages at the same firm. My approach is similar to theirs in the sense that I will also use the link between the worker’s future earnings and turnover to examine the effect of pay on turnover. However, I will use the worker’s own pay to infer his future earnings at the same firm instead of relying on similar workers’ earnings as

³Note that wage increases are tied to jobs rather than to workers in this setup. He argues that heterogeneity in within-job growth rates may arise under the assumptions of firm-specific and general human capital.

a proxy for the worker's future earnings. Munasinghe (2005), on the other hand, uses workers' own assessments regarding their expected duration at the current job, and their promotion prospects. In that way, he is able to examine the link between the worker's job prospects and his turnover behavior. He finds that workers who do not expect to remain at the current job for a long period and those with limited promotion prospects have higher turnover rates.⁴

The earlier literature that studies turnover from an efficiency point of view focuses on turnover effects of bonus payments. The idea that bonuses can be used as a retention device was first proposed by Hashimoto (1979), who attempted to explain the prevalence of bonus contracts in Japan. He argues that high profitability of investment in specific human capital, which leads to the practice of lifetime employment, is one of the main characteristics of the Japanese labor market. As a result, if spot-contracting is costly both the employer and workers have incentives to commit to a bonus contract that can prevent inefficient separations by setting a rule for the division of rents to specific human capital.⁵ Following this reasoning, he hypothesizes that the bonus-earnings ratio should increase with the profitability of investment in specific human capital. Using aggregated data from the Basic Wage Census from Japan, he finds that variables associated with higher returns to human capital such as education, firm size and tenure at the current firm have significant

⁴He also finds that workers with more favorable assessments regarding their future at the current firm have steeper downward-sloping turnover-tenure profiles.

⁵In related work, Hashimoto and Yu (1980) focus on inefficient separations that may occur due to transaction costs associated with spot contracts and opportunistic bargaining during the post-investment period. They show that one way to minimize the loss of resources due to inefficient separations is to use bonus contracts in which parties optimally share the returns to specific capital.

positive effects on the bonus-earnings ratio.

The work by Blakemore, Low, and Ormiston (1987), on the other hand, differs from Hashimoto's framework by considering a costless contracting case in which the compensation contract entails two parts. In particular, the base salary is fixed before the worker's output realization and not re-negotiable within the period, whereas the bonus pay is not fixed, but responsive to internal and external market conditions.⁶ This aspect of the two-part contract makes it a vital retention device since the firm is able to respond, for example, to outside offers made to its able employees or fluctuations in worker's marginal product by adjusting the bonus payment. Using a sample drawn from PSID 1970-81, they find evidence consistent with their hypothesis that firms use bonus plans to prevent workers' voluntary turnover.⁷

However, their empirical findings should be interpreted with caution for several reasons. First, the dataset provides information about individuals' supplementary incomes that may include bonus awards, commissions, tips, or overtime pay. However, it does not specify which form of income the individual earns. To circumvent this problem, the authors restrict their sample to prime-age male workers in management and administrator occupations. Second, as the authors cannot observe the employer source of income for a given year if the worker changes employers within a year, they use workers who have stayed with the same employer at least 12 months.

⁶Lazear (2004) makes a similar argument for CEOs' compensation. He argues that firms use stock options in order to gain the flexibility of paying CEOs more and retaining them in good states, but behaving in an opposite fashion in bad states.

⁷They also hypothesize that firms operating in industries with unpredictable demand conditions should be more likely to use two-part contracts than firms in industries facing relatively inelastic demand schedules. However, they do not test this hypothesis due to data limitations.

Third, they cannot distinguish workers who were not eligible to earn bonuses from workers who were eligible, but did not earn bonuses. Therefore, their working sample includes only bonus recipients. Finally, their statistical analysis, which provides only cross-sectional evidence, may suffer from small sample size since it uses 425 worker-years of data in estimation.

Finally, a small set of empirical papers documents the differences between salary and bonus payments. For example, Leonard (1990) finds that the elasticity of bonus pay with respect to unit sales is more than four times as high as the elasticity of salary with respect to unit sales, and that bonus payments are more variable over time than salaries. Findings of Lin (2005) are consistent with these: bonuses are more sensitive to economic conditions than salaries, and they are more dispersed than salaries within a hierarchical level. Belzil and Bognanno (2008) examine how promotions affect earnings growth in corporate hierarchies and show that promotions have a positive effect on the growth of salaries, but not on bonuses. Finally, Gibbs and Hendricks (2004) find evidence consistent with the hypothesis that firms make use of bonus payments to circumvent restrictions imposed on salaries by pay scales. The current study aims to contribute to the literature on worker turnover by examining the effects of salaries and bonus payments on turnover. As indicated, the effect of bonus payments on turnover has been paid little attention. Therefore, the primary goal of the paper is to document empirical evidence that bonus payments provide additional information in analyzing turnover after controlling for salary. As will be discussed in the next section, the current values of pay variables can be associated with the worker's future compensation at the same firm. Using this link, I will employ

the wealth maximization hypothesis to motivate empirical predictions concerning the effect of pay variables on turnover.

2.3 Theoretical Framework

In this section, I review a basic turnover model in which the worker's optimal strategy entails maximization of his expected lifetime earnings. This discussion aims to provide a theoretical framework that motivates testable predictions concerning the effect of pay on turnover.

The idea that workers aim to maximize the expected present value of their lifetime earnings can be used to provide an economic rationale for turnover (Burdett, 1978). Building upon this argument, Mortensen (1988) provides a job-search model that focuses on the worker's job separation behavior. Mortensen assumes that the worker, while employed, receives random job offers in each period and decides whether to quit his current job to start a new employment (or to move into unemployment). The worker's optimal separation decision in each period maximizes the expected present value of future earnings. In other words, the worker compares the value of his current job, which is given by the expected present value of future earnings at the same job, to the value of the outside job offered by potential employers, and chooses to quit when the latter is greater than the former.

Consistent with Jovanovic's (1979a, b) model, Mortensen assumes that the wage

process in a given job is a martingale where conditional dispersion decreases with tenure. This assumption has important consequences. First, it implies that the current wage level possesses all the necessary information to predict future wages at the same job, and that the uncertainty concerning future wages diminishes with the worker's tenure. In addition, since the worker gradually learns about his productivity at the current job and the distribution of alternative job offers is independent of the worker's productivity at the current job, holding a job has an option value.⁸ That is, the worker has the opportunity to terminate employment in the case of a bad realization. Therefore, uncertainty regarding future earnings is preferred by the worker as long as he is not too risk averse. Note that the option value of a given job decreases with the worker's tenure since the uncertainty diminishes with tenure by assumption.

In this setup, Mortensen shows that the worker's optimal separation decision satisfies the reservation property.⁹ Specifically, each worker has a reservation wage offer W_i^R so that the worker chooses to separate if the initial wage offered for an alternative job exceeds his reservation wage offer. In other words, the reservation wage offer is the minimum starting wage of an alternative job that can attract the worker. The reservation wage offer can be characterized by

$$W_{it}^R = w(w_t, w^{t+1}, \sigma_C), \quad (2.1)$$

⁸It is possible, however, to relax this assumption by assuming that the worker's productivity is correlated across jobs (MacDonald, 1988).

⁹He shows that the same property holds for the worker's decision to move into a non-employment state. In motivating the testable predictions, I interpret quits as workers leaving their current employer and moving to another job as opposed to moving into non-employment or retirement.

where w_t is the current wage level, w^{t+1} is the vector of future wages at the current job, and σ_C is the option value associated with the current job. As noted, the worker's productivity in his current job does not affect the distribution of alternative job offers since each worker draws a random job from a pre-specified distribution. Therefore, any heterogeneity concerning alternative job offers operates only through the number of job offers received in a given period (i.e., the heterogeneity is driven by the worker's search intensity). As a result, worker i 's highest alternative wage offer at time t can be written as

$$W_{it}^O = w(\eta_{it}, \sigma_O), \quad (2.2)$$

where η_{it} is the number of job offers worker i receives in period t , σ_O is the option value of holding the alternative job. To introduce separations, let y_{it} be a binary variable indicating the worker's separation decision. Then the optimal separation rule is as follows:

$$y_{it} = \begin{cases} 1, & \text{if } W_{it}^O > W_{it}^R \\ 0, & \text{otherwise.} \end{cases} \quad (2.3)$$

This framework can be used to motivate the testable predictions concerning the effect of pay variables on turnover. Before discussing the predictions, a clarification about the terminology is noteworthy. In the literature, wages refer to pecuniary returns to employment, and they are measured by either salaries or the sum of salaries and bonus payments. In this paper, however, I examine each component of the worker's compensation separately. The earnings obtained from aggregating salaries and bonus payments are referred to as total compensation. Therefore, the

counterpart of wages becomes salaries in the present paper.

The framework discussed above predicts that the current wage level is negatively related to turnover. Specifically, when the worker's tenure is held constant, i.e., the option value associated with the current job is held constant, the reservation wage offer, W_{it}^R , increases with the current wage level, w_t . Hence, the turnover rate decreases with the current wage level. However, the heterogeneity in the distribution of alternative job offers may confound this negative relationship (Galizzi and Lang, 1998). If, for example, alternative job offers are correlated with the worker's productivity at the current firm, then the current wage level may have a positive effect on turnover. One way to address this issue is to use the growth rate of wages (equivalently using the lagged value of salaries) since both the current and the lagged values of wages are correlated with the unobserved worker-specific term.¹⁰

Indeed, the same prediction can apply to total compensation. The reasoning behind this claim is that the worker may evaluate the returns to employment at the current job using the total compensation rather than salaries. In that case, the reservation wage offer decreases with the worker's total compensation in the current period, and consequently the probability of turnover decreases. Hence, to test the validity of this claim, and compare the estimated effects of salaries and total compensation on turnover, I will also estimate the effect of the total compensation in the current period.

¹⁰Note that if the wage in the previous period also correlated with the worker's alternative job offers, the same problem may persist.

Unlike the level of wages, this framework does not directly yield testable predictions concerning how the growth rate of pay variables and the size of bonus payments affect turnover. However, it can be employed to motivate the testable predictions as follows. As equation (2.1) indicates, the worker's reservation wage offer increases with the future earnings at the same job. This is quite intuitive in the sense that if the worker anticipates higher earnings at his current job, he requires a "better" job offer to leave his current employer. We can invoke this mechanism to motivate testable predictions concerning the effects of the growth rate of pay variables and the size of bonus payments. Specifically, if the current values of pay variables provide information about the worker's future compensation at the same firm, they are likely to affect turnover as well.

To this end, I make two conjectures, which I will empirically test in the present study, concerning how the current value of a pay variable relates to the worker's future compensation. First, if pay variables are serially correlated over time then their current values may be associated with their future values. Second, the current value of a pay variable can be associated with higher compensation in the future to the extent it predicts future promotions. Note that the second channel in which the current value of a pay variable (either in terms of level or growth rate) can be associated with the worker's future compensation through promotions may be evident in serial correlations as well. However, serial correlations in bonus payments do not fully capture the relationship between bonus payment in the current period and the worker's future compensation. Note that if higher bonus payments are associated with higher promotion probabilities, this means that the worker will be eligible for bonuses of

larger sizes when he is promoted, but it does not mean that the same worker will earn the bonus in future periods. However, the worker's expected compensation is likely to increase since the promoted worker earns higher salaries. Therefore, bonus payments may be associated with higher future compensation through future promotions since the promoted worker earns higher salaries and becomes eligible to earn larger bonuses.

As noted, bonus payments signal higher compensation in the future to the extent they are associated with promotions in future periods. The employer's rationale for using promotions is to sort more able workers and provide workers with incentives for effort. In either case, promotions are highly correlated with the worker's performance (Gibbs, 1995). Since bonus payments are also related to the worker's performance, it is plausible to conjecture that earning a bonus, as well as its size, is correlated with promotions. Ekinçi (2012) provides a theoretical model consistent with this reasoning. Specifically, in his model, the worker who produces a high level of output in a given period improves the employer's belief regarding his ability, and consequently earns a bonus. Since returns to ability are higher at higher job levels, the employer has incentives to assign more able workers to higher job levels. In equilibrium, workers who earn the bonus in a given period are promoted to the next job level at the beginning of the next period. There is a considerable amount of empirical evidence that promotions are associated with large wage increases (e.g., Lazear, 1992; McCue, 1996). Therefore, bonus payments signal higher expected compensation in future periods to the extent they are associated with future promotions and the corresponding wage increases.

Similarly, the growth rate of salaries may also predict higher future compensation through promotions. Baker, Gibbs, and Holmstrom (1994b) find that workers who experience higher wage growth in a given job level are more likely to get promoted to the next job level. Therefore, the growth rate of salaries can also reduce the probability of turnover through the possibility of future promotions.

Note, however, that this framework focuses on separations initiated by the worker (quits), rather than employer-initiated separations (layoffs). This might be a concern in the empirical analysis since the firm-level data does not distinguish between quits and layoffs. McLaughlin (1991) shows that if separations are efficient, distinguishing between layoffs and quits is meaningless since all workers are allocated to firms efficiently in equilibrium. However, given the empirical evidence for information asymmetries between the current employer of the worker and potential employers in the labor market (e.g., Kahn, 2009; Pinkston, 2009; DeVaro and Waldman, 2012), the efficiency assumption is a strong one. However, the main goal of the paper is not to present a theory that can fully explain turnover, but to document the effects of pay variables on turnover. Therefore, this caveat does not lessen the significance of the empirical results presented in the paper.

Overall, I will test several predictions concerning the effects of pay variables on turnover. These predictions are as follows. First, the level of salary (and total compensation) has a negative effect on turnover. Second, the growth rate of salary (and total compensation) has a negative effect on turnover. Third, both earning a bonus and the size of the bonus are negatively related to turnover after controlling

for salary and growth rate of salary.

2.4 Data

2.4.1 Firm-Level Data

The main empirical analysis in this paper is based on data coming from the personnel records for managerial employees of a medium-sized U.S. firm in the financial services industry. The same dataset was first used by Baker, Gibbs and Holmstrom (hereafter BGH) (1994a, b) in their canonical study that gave a very detailed account of the firm's wage, promotion and other personnel policies.¹¹ The original dataset includes year-end-records over the twenty-year period 1969-1988. However, information on bonus payments is available only in the last seven-year period of the data, 1981-1988.¹² Therefore, the empirical analysis that makes use of bonus payments uses only this sub-period of the data. I further restrict the analysis to U.S. male workers since all pay variables are denominated in U.S. dollars and other dynamics that may affect the turnover behavior of foreign and female workers confound the relationship between turnover and pay variables, which is the main focus of this paper. Overall, the full sample includes 31,524 worker-years of data, while the restricted sample, which consists of workers who are eligible to earn bonuses, includes 10,575 worker-

¹¹Recent papers that use the same data include Gibbs (1995), Kahn and Lange (2010), Ekinici (2012), and DeVaro and Waldman (2012).

¹²As a robustness check, I examine the extent to which the effects of functions of salary on turnover are comparable across pre- and after-1981 periods.

years of data.

To derive a turnover variable, I make use of the panel dimension of the data. Specifically, if there is no record for a worker in a given year, the previous year becomes his last year at the firm. This way of calculating the turnover variable has two implications. First, turnover is not possible for observations in last year of the dataset, 1988, since we cannot know if workers leave or stay at the firm in the following year.¹³ Second, it does not distinguish quits from layoffs. However, this is not a major limitation since the main goal of the analysis is to document that salary and bonus payments are important determinants of turnover.

An important aspect of the data is that they include performance ratings that are based on subjective evaluations submitted by supervisors. Despite their subjectivity, Gibbs (1995), using the same dataset, finds that performance ratings are correlated with promotions and bonuses, which are generally regarded as workers' being rewarded for their good performance. Therefore, I will use ratings to control for the worker's performance level.¹⁴ Subjective performance ratings are measured on a five-point scale in which 1 reflects the best performance. Since there are few worker-years at which the performance rating is equal to 5, I combine rating 5 with rating 4.¹⁵

The use of performance ratings as a control variable has several purposes. First,

¹³Note that this is a restriction only when the variable of interest is turnover. Therefore, observations in year 1988 are included in regressions in which the dependent variable is not turnover.

¹⁴Kahn and Lange (2010), and DeVaro and Waldman (2012) also use performance ratings as a proxy for the worker's performance.

¹⁵Results do not change when rating 4 and rating 5 enter regressions separately.

it is plausible to presume that the worker's separation depends on his performance. Therefore, performance ratings, which are proxies for the worker's performance level, are expected to be correlated with turnover. Second, performance ratings are correlated with promotions (Gibbs, 1995). Because promotions are associated with large increases in wages, higher performance ratings in the current period may signal higher future compensation. Therefore, workers with higher performance ratings are expected to be less likely to leave the firm. Third, Medoff and Abraham (1981) and Dohmen (2004) find that performance evaluations in the current period are correlated with future wage increases. Finally, as will be discussed in detail, performance ratings are correlated both with the probability of earning a bonus and the size of the bonus payment. Therefore, one needs to control for workers' performance to account for heterogeneity in bonus payments that arise from workers' different performance levels. However, as the theoretical discussion suggests bonus payments may provide information about the worker's performance as well. Therefore, I will examine the effects of bonus payments when the performance ratings are controlled for as well as the case when they are not included in the estimating equation. Note that if we postulate that bonus payments possess information about the worker's performance, we anticipate that the effect of bonus payments on turnover will decline when we control for performance ratings.

Another important aspect of the data set is that it includes hierarchical levels. Since the HR department of this firm did not provide any information about job levels, BGH used movements between job titles to identify job levels. Note that if information about pay variables was used in constructing job level, a part of the

correlation between turnover and pay variables would be inadvertently captured by job levels.¹⁶ BGH (1994a) identify 8 levels, where level 8 reflects the CEO of the company. Since the dynamics that determine the CEO's compensation is different and there are fewer employees at higher levels due to the pyramidal structure of the firm, I drop observations in level 8 and combine levels 6 and 7 with level 5. There are three main reasons to include job level in the empirical analysis. First, as will be discussed in detail in the next section, turnover rates depend on job level. Second, the probability of promotions depends on job levels (Gibbs, 1995). Third, the size of bonus payments increases with job level (e.g., Baker, Gibbs, and Holmstrom, 1994a; Smeets and Warzynski, 2008; Ekinici, 2012).

Table 2.1 presents means and standard deviations of key variables used in the empirical analysis.¹⁷ All pay variables are measured in real terms in 1988 dollars, while age and tenure variables are measured in years. In order to examine if observable characteristics are significantly different across two subsamples, 'leavers' and 'stayers', average values are computed separately for each group and t-statistics for the differences between the means are reported in column 6. We find that, the group of stayers is on average older, less educated, and has longer tenure at the firm. In terms of performance measures, stayers have higher performance ratings as expected.

¹⁶Lazear (1992) uses average pay to identify job levels. Therefore, any correlation between turnover and pay variables in his data would be biased downward since a part of the correlation is captured by job levels which in turn are identified by pay variables.

¹⁷The calculations are based on the sample of male workers who were employed at the firm's U.S. plants in 1981-1988, and were eligible for bonus payments. The statistics for performance ratings are based on worker-years for which performance ratings are available. The last column reports t-statistics for the mean differences between the subsamples of stayers and leavers. Throughout the paper, statistical significance at the 5%, and 1% levels is denoted by *, and **, respectively.

Table 2.1: Summary Statistics (Firm-Level Data)

Variables	Leave=0		Leave=1		t-statistic
	Mean	Std Dev	Mean	Std Dev	
Age	40.887	8.853	37.864	9.478	12.59**
High School	0.334	0.472	0.215	0.411	9.56**
College	0.327	0.469	0.410	0.492	-6.52**
Professional	0.242	0.428	0.289	0.453	-4.076**
PhD	0.095	0.293	0.086	0.280	1.17
Tenure at firm	6.397	4.107	5.282	3.859	9.77**
Tenure at level	3.872	3.177	3.433	2.858	5.16**
Level=1	0.153	0.360	0.181	0.385	-2.86**
Level=2	0.211	0.408	0.225	0.418	-1.23
Level=3	0.273	0.445	0.270	0.444	0.19
Level=4	0.321	0.467	0.301	0.459	1.59
Level=5	0.041	0.199	0.022	0.147	3.69**
Rating	1.881	0.729	2.101	0.790	-9.10**
Earned bonus	0.400	0.490	0.325	0.469	5.71**
Log(bonus)	8.728	0.863	8.690	0.959	0.95
Log(salary)	10.914	0.402	10.887	0.394	2.53*
N(worker-yrs)	13,001		1,543		

Finally, we observe that stayers have higher salaries and they are more likely to earn a bonus than leavers. Note that there is no statistical difference between bonus payments across the two groups. However, this comparison includes only bonus recipients.¹⁸

As will be discussed in the empirical section, both the probability of earning a bonus and its size are positively correlated with the worker's performance. Hence, the sample of bonus recipients may constitute a selected sample of workers who are more productive, thus less likely to leave the firm than workers who did not earn the

¹⁸Since log of 0 is undefined, observations with zero bonuses are excluded from this comparison.

bonus in the current period. This sample selection indicates an upward bias for the effect of bonuses on turnover. In order to circumvent the problem of sample selection on bonuses, I replace 0 bonuses with a very small number so that the log of it is well-defined.¹⁹ This specification allows me to use both recipients and non-recipients in regressions analyses of bonus payments.

2.4.2 PSID Sample

The PSID sample used in this empirical analysis comes from the biennial surveys in 2003-2009. It includes male household heads who are employed in a given survey year. I exclude self-employed, disabled, and government workers, students, and retired individuals from the sample. For each survey year, the respondent is asked whether he had changed his main job in the corresponding year, and the reason for his job mobility if applicable. Following McLaughlin (1991), I define the layoff variable so that it includes separations due to being laid-off and the company being shut down, and define the quit variable so that it includes only voluntary separations.

Summary statistics for variables used in the empirical analysis are reported in Table 2.2. To be able to assess differences in observed characteristics statistics are reported separately for the whole sample, ‘stayers’, ‘layoffs’ and ‘quits’. The last column reports the t-statistics for the mean differences between layoffs and quits. We observe that on average laid-off workers are older, more likely to be married, and

¹⁹When I used the subsample of bonus recipients in bonus regressions, the results were qualitatively similar to those reported in the paper.

Table 2.2: Summary Statistics (Sample from the PSID)

Variables	Whole Sample		Stayers		Layoffs		Quits		t-stat
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
Log(salary)	10.46	0.87	10.51	0.82	9.92	1.01	9.53	1.22	4.68**
Log(bonus)	0.86	2.43	0.89	2.47	0.47	1.75	0.44	1.63	0.17
High school	0.36	0.48	0.36	0.48	0.51	0.50	0.41	0.49	2.53*
College	0.21	0.41	0.22	0.41	0.14	0.35	0.18	0.31	1.17
Grad	0.05	0.21	0.05	0.21	0.02	0.13	0.01	0.12	0.29
Age	40.3	11.6	40.5	11.6	37.9	11.4	34.8	12.1	3.51**
Married	0.72	0.45	0.73	0.44	0.54	0.49	0.42	0.50	3.18**
Tenure	7.38	8.47	7.66	8.57	3.56	5.26	2.74	4.69	2.05*
Proportions	1		0.937		0.038		0.0141		
N(worker-yrs)	15854		14870		617		224		

they earn higher salaries and have longer tenure than quitters have.

2.4.3 Estimation Framework

Since the dependent variable of interest is a dichotomous variable, I make use of the logit estimator which also enables me to exploit the panel dimension of the data. In particular, I adopt the following underlying latent model:

$$\begin{aligned}
 y_{it}^* &= W_{it}^O - W_{it}^R \\
 &= \alpha_i + p_{it}'\gamma + x_{it}'\beta + \epsilon_{it}
 \end{aligned}
 \tag{2.4}$$

where y_{it}^* is a continuous but unobserved index of propensity to turnover of worker i in period t , p_{it} is the vector of pay variables, which are of primary interest, x_{it} is a vector of explanatory variables (that will be discussed below), and α_i is an idiosyncratic fixed effect which accounts for unobserved and time-invariant heterogeneity between

workers' propensity to turnover. Since what we observe is an indicator variable concerning whether worker i is still employed at the firm in period $t+1$ provided that the worker has worked with his current employer for t periods, we have:

$$y_{it} = \begin{cases} 1, & \text{if } y_{it}^* > 0 \\ 0, & \text{otherwise.} \end{cases} \quad (2.5)$$

When ϵ_{it} is independently logistic, we have:

$$Pr(y_{it}^* = 1 | \alpha_i, p'_{it}, x'_{it}) = \frac{\exp(\alpha_i + p'_{it}\gamma + x'_{it}\beta)}{1 + \exp(\alpha_i + p'_{it}\gamma + x'_{it}\beta)}. \quad (2.6)$$

Following Chamberlain (1984), I estimate this fixed-effects logit model by conditional maximum likelihood.²⁰ However, this approach relies on observations in which there is a change in the dependent variable from zero to one or vice versa, thus it entails a loss of observations.²¹ Also, since we have firm-level data in which workers are not followed after leaving the firm, we use observations for which the dependent variable changes from zero to one to estimate our model. Hence, in order to check the robustness of our results, I report results from pooled regressions as well as fixed-effects regressions.²²

²⁰Note that this estimator does not treat worker fixed-effects as parameters to be estimated.

²¹This loss of observations does not indicate a loss of information since observations in which there is no change in the dependent variable do not contribute to the likelihood function (Wooldridge, 2010).

²²Note that we do not use the random effects specification since its assumption of independence between the individual fixed effect and the explanatory variables makes this strategy unappealing in the current context.

2.5 Results

The empirical analysis consists of two parts. In the first part, I use the firm-level data to examine the effects of pay variables on turnover. In the second part, I use the sample drawn from the PSID to examine the extent to which the findings from the firm-level analysis are robust to heterogeneity in firms' personnel policies. This part of the analysis will also let us examine if there are any behavioral differences between quits and layoffs.

2.5.1 Analysis on the Firm-Level Data

In the firm-level analysis, I make use of the detailed information about workers' pay variables, performance, and tenure to investigate the effects of pay variables on turnover. To this end, I will first focus on the firm's policy on bonus payments. In particular, I will examine the probability of earning a bonus and the size of bonus payments. This discussion will provide a basic understanding of the firm's bonus policy; thus, it will help interpret the effect of bonus payments on turnover. Next, I will examine the extent to which the current values of pay variables can be associated with future compensation, and look at the exit patterns within pay distributions. In the last subsection, I will estimate the effects of pay variables on turnover, and discuss the results.

Preliminary Analysis on Bonus Payments

Before turning to the effect of bonus payments on turnover, I will first provide a general discussion of bonus payments. As indicated, workers do not earn bonuses in each period they are eligible for bonuses. Therefore, the subsample of eligible workers includes worker-years of data with positive (recipients) as well as zero bonuses (non-recipients). To investigate how the worker's (observable) characteristics, job level and performance ratings are related to the worker's probability of earning the bonus and to the size of bonus payments, I conduct an analysis on bonuses and report the results in Table 2.3.²³

The first column reports the results from a logit model with the dependent variable indicating whether the worker is a bonus recipient in the current period, or not. Two important conclusions can be drawn here: first, job levels have significant effects on the probability of earning a bonus;²⁴ second, performance ratings are strongly correlated with the probability of earning a bonus. Specifically, the worker's probability of earning the bonus increases monotonically with his performance. In addition, the probability of earning a bonus is increasing with the worker's tenure at the firm. One explanation for this finding is that the worker accumulates human capital over time, and he becomes more likely to earn a bonus as he becomes more productive over time.²⁵

²³All specifications include control variables for education, race, age, and year dummies. 'Level=1' and 'Rating=1' are the omitted categories. Pseudo- R^2 refers to McFadden's R^2 . Standard errors are provided in brackets.

²⁴The p-value of the F-test for the joint significance of job level dummies is practically zero.

²⁵Another explanation is that the more senior workers have superior information about the per-

Table 2.3: Determinants of Bonuses (Firm-Level Data)

Variables	Earned Bonus (Logit)	Bonus (OLS)	Log(bonus) (OLS)	Bonus (Tobit)
Level=2	0.332** (0.0918)	393.2** (148.0)	0.370** (0.0479)	3,048** (772.7)
Level=3	0.930** (0.0942)	1,343** (210.7)	0.638** (0.0493)	7,900** (977.5)
Level=4	0.891** (0.105)	4,255** (371.1)	1.216** (0.0552)	11,477** (1,196)
Level=5	0.923** (0.192)	19,218** (2,380)	2.594** (0.106)	30,301** (3,180)
Rating=2	-0.547** (0.0509)	-1,552** (211.5)	-0.122** (0.0208)	-4,503** (559.4)
Rating=3	-1.618** (0.0847)	-2,280** (195.0)	-0.0933* (0.0392)	-12,620** (1,148)
Rating=4	-2.228** (0.340)	-2,806** (568.5)	0.421 (0.279)	-16,561** (3,243)
Tenure at firm	0.158** (0.026)	68.32 (93.28)	-0.0206 (0.012)	710.1** (228.0)
Tenure at firm ²	-0.0077** (0.001)	-5.073 (4.528)	0.0012 (0.001)	-34.31** (12.28)
N(worker-yrs)	10,567	10,575	3,508	10,575
Log-likelihood	-5765	-110220	-3030	-41760
Pseudo-R ²	0.141	0.149	0.485	0.0247

Next, I focus on the size of bonus payments. Accordingly, I estimate three models to understand whether using the sample of bonus recipients affects the impact of explanatory variables on the size of bonuses. Columns 2 and 3 report the results from the ordinary least squares estimation in which the dependent variable is bonus payments and the logarithm of bonus payments, respectively. Note that the results reported in column 2 include all observations, whereas the results reported in column 3 include only bonus recipients (since the logarithm of zero is undefined). We see performance requirements for earning a bonus than younger workers.

that even though sample sizes are substantially different (10,575 vs. 3,508), the point estimates for job levels have the expected pattern in both regressions. Consistent with the existing literature, each regression indicates that the size of bonus payments increases with job level. The estimated effect of performance ratings, on the other hand, differs in the two regressions. The results in column 2 indicate that the size of bonus payments increases with the worker's performance, whereas the results in column 3 do not indicate a monotonic relationship. One potential reason for this finding is that the subsample of bonus recipients consists of worker-years with high performance ratings.²⁶ Therefore, controlling for performance ratings does not yield a monotonic relationship since only few observations with lower ratings are included in the subsample of bonus recipients.

Finally, I employ tobit estimation to address potential selection problems due to the clustering of workers with zero bonuses. Indeed, the results from the tobit regression, reported in column 4, are also in line with linear regressions in terms of understanding the qualitative effects of observable characteristics on bonuses. They all indicate that the size of bonus payments increases with job level and performance ratings. Note, however, that tobit regression results are the only set of results that produce significant effects for the worker's tenure at the firm.

Overall, the results suggest that the subsample of bonus recipients constitute a selected sample in the sense that it consists of worker-years with higher performance on average. Note that this result is valid to the extent that performance ratings

²⁶As the results in column 1 indicates, it is less likely to observe a positive bonus in a given worker-year with lower performance ratings.

are a good measure for the worker's performance. Since there might be a selection problem associated with the subsample of bonus recipients, it is important to make use of both bonus recipients and non-recipients in the empirical analysis of turnover.

The Link between the Current Values of Pay Variables and Future Compensation

I begin the analysis by examining the serial correlation in pay. The goal of this exercise is to assess the extent to which the value of pay variables at the current period is associated with their future values. In that sense, if pay variables are highly correlated over time, one can argue that the current values of pay variables provide information about the worker's future compensation, and they are likely to affect turnover.

Table 2.4 reports serial correlations of total compensation, salaries, and bonus payments between three adjacent years. The results indicate that the level of total compensation is highly correlated over time, both in adjacent periods and two-period windows. The same pattern is observed for the level of salary with higher correlations. Accordingly, the serial correlation in the level of salary at the current period is close to 1 both for 1 period and 2 periods back. The serial correlations in bonuses, on the other hand, are weaker, but they are also significant and positive. This explains why the serial correlation in total compensation is weaker than that in salaries; the fact that bonuses are less correlated over time weakens the serial correlation in total compensation.

Table 2.4: Serial Correlations in Pay (Firm-Level Data)

Pay Variables	Correlation between pay variable in the current period and:		Correlation between residual pay variable in the current period and:	
	1 period back	2 periods back	1 period back	2 periods back
Log(compensation)	0.973*	0.843*	0.719*	0.694*
Δ Log(compensation)	-0.017	-0.022	-0.112*	-0.073*
Log(salary)	0.985*	0.956*	0.693*	0.656*
Δ Log(salary)	0.325*	0.276*	0.178*	0.138*
Log(bonus)	0.207*	0.193*	0.171*	0.148*

Looking at the serial correlations in growth rates, we observe a striking difference between total compensation and salary.²⁷ Specifically, the serial correlation in the growth rate of salaries is positive (and statistically significant), whereas the serial correlation in the growth rate of total compensation is negative and not statistically significant. This disparity follows from the fact that workers do not earn bonuses in each period. Therefore, the growth rate in total compensation has a considerably different pattern over time than the growth rate in salaries. Finally, a finding common to both levels and growth rates of pay variables is that the correlation is slightly stronger for adjacent years than the correlation between the current period and two periods back.

To what extent these serial correlations are driven by heterogeneity in workers or jobs (or a combination of the two) is important. In other words, these correlations may be driven by differences in observable characteristics of workers. For example,

²⁷Since there are few workers who are eligible for bonuses in subsequent periods, the empirical analysis does not include the growth rate of bonus payments.

workers at higher job levels or workers with longer tenure at the firm may receive higher salary increases or bonuses, or other observable characteristics such as education or race may have systematic effects on pay variables. To account for these possibilities, I compute abnormal variation in pay variables (residuals) after controlling for age, tenure at the firm, education, race, job level and salary (for bonus regressions only). Columns 4 and 5 report the serial correlations in residuals in three adjacent years. As expected, serial correlations in salaries and bonus payments are somewhat smaller, but still significant at the 1 percent level. Interestingly, the serial correlation in the growth rate of total compensation becomes negative and statistically significant at the 1 percent level after controlling for the worker's observable characteristics. As indicated, the negative relationship is mostly due to bonus payments. Since workers do not earn bonuses in each period, the growth rate of total compensation is not as predictable. Therefore, if we account for observable factors that are correlated with bonuses, such as job levels, the serial correlation in total compensation becomes less sensitive to the over-time variation in bonus payments. Overall, the results indicate that even though observable characteristics have an important effect, the serial correlations remain statistically significant.

Next, I investigate the extent to which pay is associated with promotions. To investigate the effect of pay on promotions, I estimate logit models with the dependent variable indicating whether the worker earns a promotion in a given year. The results are reported in Table 2.5. In addition to performance ratings and tenure at the current job level, each specification includes controls for job level, education, race, and age. Consistent with the earlier literature, both performance ratings and tenure

Table 2.5: Promotions and Pay (Firm-Level Data)

Variables	[1]	[2]	[3]	[4]	[5]	[6]
Rating=2	-0.407** [0.0784]	-0.393** [0.0850]	-0.396** [0.0786]	-0.412** [0.0842]	-0.389** [0.0787]	-0.335** [0.0965]
Rating=3	-1.339** [0.117]	-1.235** [0.124]	-1.266** [0.118]	-1.269** [0.124]	-1.256** [0.118]	-1.161** [0.143]
Rating=4	-2.467** [0.595]	-2.307** [0.598]	-2.504** [0.596]	-2.496** [0.597]	-2.500** [0.596]	-1.903** [0.609]
Tenure at level=2	1.046** [0.0961]	1.125** [0.115]	1.081** [0.0959]	1.026** [0.115]	1.078** [0.0959]	0.855** [0.113]
Tenure at level=3	0.991** [0.115]	1.087** [0.130]	1.050** [0.115]	0.997** [0.129]	1.047** [0.115]	0.717** [0.133]
Tenure at level=4	0.689** [0.148]	0.837** [0.160]	0.750** [0.148]	0.703** [0.159]	0.746** [0.148]	0.463** [0.176]
Tenure at level \geq 5	0.999** [0.129]	1.145** [0.141]	1.095** [0.129]	1.046** [0.140]	1.094** [0.129]	0.703** [0.158]
Log(salary)	1.135** [0.164]					
Δ Log(salary)		3.837** [0.593]				
Earned bonus			0.442** [0.0731]	0.437** [0.0803]		
Earned bonus last period				0.129 [0.0863]		
Log(bonus)					0.0370** [0.0057]	0.0251** [0.0071]
Log(bonus last period)						0.0228** [0.0076]
N(worker-yrs)	11,763	11,124	11,764	11,126	11,763	6,855
Log-likelihood	-3059	-2783	-3065	-2786	-3062	-2015
Pseudo-R ²	0.197	0.202	0.196	0.202	0.196	0.192

at the current job level are strongly correlated with the probability of promotions (Gibbs, 1995). The results show that both the level and the growth rate of salaries have a statistically significant positive effect on the probability of promotions (see columns 1 and 2). This result is consistent with the finding that workers with higher wage growth are more likely to earn a promotion (BGH, 1994b).

More interestingly, the findings indicate that having earned a bonus, as well as the size of the bonus, is correlated with promotion. The results in column 3 show that workers who have earned a bonus in the current period are more likely to earn a promotion.²⁸ We see that the effect of earning a bonus in the previous year is positive, but not significant at conventional levels (see column 4). The estimated effects of the size of bonus payments are in line with our expectations. Specifically, the size of bonus payments is positively related to the probability of earning a promotion (see column 5). The same result holds for the bonus payment in the previous year as well. In column 6, we see that the sizes of bonus payments in both the current and the previous periods have positive effect on the probability of earning a promotion.

One pattern observed in Table 2.5 is that functions of salary have larger effects on the probability of earning a promotion than bonus variables. For example, the marginal effect of the salary level is 3 times larger than the marginal effect of earning a bonus in the current period. The difference gets even larger between the salary level and the size of bonus payments.²⁹ Therefore, we can argue that the predictive power

²⁸Since the data provide a snapshot for each year, we do not know the exact timing of promotion decisions. Therefore, this finding indicates that the worker who earns a bonus in the current period is more likely to be assigned to the next job level in the next period.

²⁹Also, note that the point estimate for growth rate of salary is larger than that for the level of

of bonus payments is considerably smaller than that of salary variables. Therefore, the link between the current value of bonus payments and future compensation is weaker than it is between salary variables and future compensation. In that sense, this result is consistent with the discussion concerning serial correlations. Recall that the serial correlation in bonus payments is weaker than the serial correlation in salary variables. The reason for this is that bonus payments are erratic in the sense that the worker may not earn bonuses in subsequent periods. Consequently, we anticipate that the effect of bonus payments on turnover will be weaker than the effect of salaries since the association between bonus payments and future compensation is weaker.

Exit Rates and Pay Distributions

Here, I examine exit rates by job level and pay decile. Pay deciles are calculated within each hierarchical level and year. Therefore, one can see how exit rates vary across pay deciles within a job level. Table 2.6 presents exit rates by job level and salary decile. The results indicate that there is little variation in exit behavior across salary deciles. Across levels, on the other hand, workers at levels 3 and 4 are more likely to leave the firm than other job levels. Tables 2.7 and 2.8 examine the pattern of exit rates by job level and deciles of salary increase, and bonus payments, respectively. Looking at the salary increase and exit rates, two patterns are noticeable in all job levels but level 5: first, exit rates are highest in the bottom decile and decrease afterwards; second, exit rates start to increase in the highest two deciles. On the salary. This suggests that the former has a more predictive power on promotions than the latter.

other hand, the relationship between bonus payments and exit rates are erratic, especially in levels 1 and 5.

Table 2.6: Separation Rates by Job Level and Salary Decile (Firm-Level Data)

Level	Bottom	2nd	3rd	4th	5th	6th	7th	8th	9th	Top	Total
1	0.120	0.104	0.106	0.107	0.109	0.123	0.091	0.108	0.127	0.092	0.108
2	0.097	0.088	0.105	0.103	0.106	0.088	0.098	0.111	0.094	0.089	0.098
3	0.108	0.093	0.082	0.098	0.069	0.421	0.100	0.104	0.087	0.123	0.126
4	0.089	0.064	0.077	0.096	0.095	0.722	0.076	0.098	0.085	0.093	0.150
5	0.149	0.146	0.132	0.066	0.104	0.063	0.048	0.048	0.058	0.029	0.083
Total	0.104	0.089	0.092	0.098	0.093	0.074	0.088	0.1	0.091	0.095	

Table 2.7: Separation Rates by Job Level and Salary Increase Decile (Firm-Level Data)

Level	Bottom	2nd	3rd	4th	5th	6th	7th	8th	9th	Top	Total
1	0.184	0.111	0.082	0.074	0.085	0.088	0.067	0.075	0.043	0.121	0.093
2	0.165	0.107	0.083	0.059	0.095	0.092	0.083	0.074	0.092	0.111	0.096
3	0.158	0.075	0.079	0.089	0.066	0.082	0.085	0.073	0.089	0.097	0.089
4	0.157	0.096	0.079	0.069	0.071	0.083	0.068	0.065	0.067	0.091	0.085
5	0.085	0.155	0.117	0.103	0.068	0.113	0.031	0.069	0.01	0.01	0.076
Total	0.157	0.098	0.082	0.075	0.075	0.087	0.073	0.07	0.072	0.095	

Table 2.8: Separation Rates by Job Level and Bonus Decile (Firm-Level Data)

Level	Bottom	2nd	3rd	4th	5th	6th	7th	8th	9th	Top	Total
1	0.087	0.17	0.205	0.057	0.2	0.028	0.127	0.128	0.115	0.164	0.129
2	0.143	0.083	0.127	0.08	0.094	0.03	0.098	0.09	0.033	0.096	0.087
3	0.107	0.076	0.059	0.068	0.067	0.103	0.068	0.046	0.059	0.113	0.074
4	0.073	0.103	0.106	0.063	0.062	0.091	0.087	0.071	0.071	0.111	0.085
5	0.179	0.036	0.029	0.028	0.108	0.143	0.065	0.056	0.083	0.071	0.079
Total	0.103	0.096	0.096	0.065	0.08	0.086	0.085	0.067	0.067	0.111	

Interestingly, workers at top deciles leave the firm more often than worker at lower levels. One possibility is that the firm has limited slots to grant promotions to its employees (a situation referred to as promotion bottlenecks). Hence, workers who

are not granted a promotion leave the firm since their earnings cannot go beyond the upper limit imposed by pay scales unless they are promoted to the upper job level. The constraint on pay raises imposed by pay scales was referred to as the ‘Green Card’ effect by BGH (1994a). This effect implies that workers at lower pay deciles in a given job category experience higher raises than workers at higher pay deciles at the same job category. Therefore, the finding that workers at top pay deciles are more likely to separate is consistent with the green card effect in the sense that workers who are not satisfied with their pay raises may have higher propensities to separate. Another possibility is that workers in higher deciles have higher levels of general human capital; thus, they are more mobile or have higher demand from the labor market.

Pay Variables and Turnover

After establishing the link between the current values of pay variables with the worker’s future compensation, I test the predictions concerning the effects of salaries and bonus payments on turnover. To investigate the effect of pay variables on turnover, I estimate equation (2.6) under several specifications. In particular, I first examine how the level and the growth rate of salaries affect the probability of turnover. This analysis is based on the full sample.³⁰ Next, I estimate the effect of functions of bonus after controlling for salary (both its level and growth rate). Since bonuses are available only in the restricted sample, this analysis is based only on the

³⁰As a robustness check, I also estimate the effect of salaries on turnover using the restricted sample which is the subsample of workers who are eligible for bonuses.

restricted sample. Finally, I replace salary with total compensation (equal to the sum of salaries and bonus payments) to assess to what extent aggregating salaries with bonus payments changes the results.

As discussed in the previous section, both fixed-effects and pooled logits are estimated to assess how unobserved worker heterogeneity affects workers' propensities to turnover. All pooled logits include age, tenure at firm, education level, year dummies, and race dummies as control variables, whereas these variables are dropped in fixed-effects estimations. Overall, I estimate three different specifications for each pay variable under consideration. The baseline specification includes the set of control variables enumerated above (only for pooled regressions) and indicator variables for job levels. The second specification augments the baseline with indicator variables for performance ratings, while the third specification further augments it by adding indicator variables for tenure at the current job level. As indicated, the rationale for using performance ratings and tenure at the current job level in turnover regressions is to account for the worker's current performance and his future promotion possibilities, respectively. Therefore, we anticipate that the negative effect of pay variables on turnover should decline in the second and the third specifications.

Table 2.9 displays the results of estimating logit models in which the pay variable of interest is salary and the estimation is based on the full sample. Panel A displays the results for the pooled logits, while Panel B displays the results for the FE logits. The results from pooled logits (columns 1 to 3 on Panel A) indicate that the level of salary does not have a significant effect on turnover. On the contrary, the FE logits

Table 2.9: The Effect of Salary on Turnover

Variables	A. Pooled Logits						B. Fixed-Effects Logits					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
Log(salary)	-0.124 [0.0943]	0.223 [0.128]	0.0696 [0.132]				7.107** [0.381]	9.193** [0.631]	4.441** [0.930]			
Δ Log(salary)				-6.495** [0.435]	-3.794** [0.539]	-3.432** [0.544]				-7.317** [0.544]	-7.403** [0.846]	-2.632* [1.119]
Level=2	0.233** [0.0553]	0.190** [0.0695]	0.300** [0.0722]	0.252** [0.0661]	0.257** [0.0778]	0.348** [0.0818]	4.276** [0.385]	4.582** [0.599]	11.79** [0.858]	4.486** [0.458]	5.228** [0.727]	12.94** [0.962]
Level=3	0.295** [0.0654]	0.274** [0.0841]	0.434** [0.0889]	0.395** [0.0706]	0.406** [0.0855]	0.516** [0.0895]	7.651** [0.462]	7.998** [0.703]	21.53** [1.243]	8.418** [0.531]	9.349** [0.821]	23.39** [1.360]
Level=4	0.368** [0.0927]	0.362** [0.123]	0.572** [0.129]	0.519** [0.0800]	0.605** [0.102]	0.707** [0.104]	10.91** [0.577]	12.61** [1.239]	32.78** [1.972]	12.97** [0.679]	15.97** [1.385]	35.19** [2.078]
Level=5	0.255 [0.196]	0.212 [0.306]	0.544 [0.310]	0.322 [0.176]	0.529 [0.281]	0.669* [0.282]	12.44** [0.782]	14.48** [1.636]	42.96** [2.614]	15.72** [0.885]	18.72** [1.652]	45.58** [2.687]
Rating=2		0.379** [0.0578]	0.350** [0.0583]		0.288** [0.0669]	0.278** [0.0670]		1.000** [0.136]	0.853** [0.214]		0.973** [0.137]	0.858** [0.208]
Rating=3		0.937** [0.0751]	0.859** [0.0768]		0.740** [0.0861]	0.709** [0.0864]		2.400** [0.165]	1.714** [0.251]		2.026** [0.168]	1.570** [0.247]
Rating=4		1.897** [0.184]	1.791** [0.185]		1.556** [0.196]	1.527** [0.196]		4.343** [0.320]	3.248** [0.411]		3.093** [0.307]	2.855** [0.408]
Tenure at level=2			0.171* [0.0669]			0.0960 [0.0774]			2.948** [0.249]			2.617** [0.257]
Tenure at level=3			0.305** [0.0871]			0.215* [0.0925]			5.471** [0.341]			5.287** [0.355]
Tenure at level=4			0.408** [0.107]			0.306** [0.111]			7.844** [0.426]			7.840** [0.447]
Tenure at level \geq 5			0.559** [0.111]			0.474** [0.113]			10.78** [0.508]			10.90** [0.539]
N(worker-yrs)	31,524	21,153	21,153	25,614	18,145	18,145	18,270	7,950	7,950	14,406	6,736	6,736
N(workers)	6,186	5,068	5,068	4,987	4,422	4,422	3,237	1,791	1,791	2,532	1,522	1,522
Log-likelihood	-10380	-6617	-6603	-8044	-5565	-5555	-3370	-1407	-720.8	-2876	-1353	-700.0
Pseudo-R ²	0.0361	0.0568	0.0588	0.0515	0.0595	0.0611	0.314	0.411	0.698	0.258	0.336	0.657
AIC	20827	13307	13288	16154	11200	11188	6750	2829	1465	5761	2722	1424
BIC	21111	13602	13614	16423	11473	11493	6789	2885	1549	5799	2777	1505

imply that the coefficient estimates for the level of salary is positive and significant at the 1 percent level (see columns 1 to 3 on the second panel). This means that workers with higher salaries are more likely to turnover even after controlling for time-invariant worker heterogeneity. As discussed earlier, this finding is inconsistent with the search theories predicting that the probability of turnover declines with the current wage level. However, there is no consensus in the empirical literature about the effect of current salary level on turnover. For example, Galizzi and Lang (1998) also find a positive relationship between the current wage level and turnover. A possible explanation for this finding might be that higher salaries reflect workers for which the labor market demand is higher. For example, if the skills of workers with higher salaries are more transferable to other firms in the market, they are more likely to receive wage offers higher than their current compensation.³¹ However, the data do not permit us to test this hypothesis.

Unlike the level of salary, the growth rate of salary has a negative and statistically significant (at the 1 percent level) effect on turnover. Specifically, both pooled logits (columns 4 to 6 on Panel A) and FE logits (columns 4 to 6 on Panel B) indicate that the worker's probability of turnover declines with the growth rate of salary in the current period. Recall that the conjecture of the paper is the growth rate of salaries is positively related to the worker's future compensation, thus it has a negative effect on turnover. Therefore, one expects that the effect of the growth rate of salary on turnover should decline, in absolute terms, when we account for the worker's cur-

³¹Consistent with this argument, Murphy and Zbojnik (2004) show that an increase in the transferability of the worker's skills (i.e., an increase in the ratio of general to firm-specific human capital) leads to fewer internal promotions, more external hires, and an increase in average wages.

rent performance and his promotion prospects. The results are generally consistent with this postulate; the point estimate for the growth rate of salary decreases after controlling for performance ratings and tenure at the current job level. Indeed, the decrease is more dramatic in FE logits since the point estimate almost reduces to the one third of its level in the baseline specification. Before turning to other pay variables, let us look at how the control variables for the worker's performance and promotions prospects are related to turnover. The results show that the point estimates for performance ratings and tenure at the current level are in line with our expectations. The probability of turnover decreases with the worker's performance. The relationship between the probability of turnover and dummies for tenure at current job level, which are intended to capture the variation in promotion probabilities, is monotonic. Workers with longer tenure at the current job level are more likely to turnover after controlling for the worker's tenure at the firm. This suggests that the tenure at the current level can be used to control for the worker's promotion prospects.

As noted before, the analysis on bonus payments is based on the restricted sample since the bonus data span the 1981-1988 period. I perform two robustness checks. First, I re-estimate all specifications reported in Table 2.9, which are based on the full sample, using the restricted sample to see if results discussed above are robust to time period. Results from the restricted sample are qualitatively the same and quantitatively very similar to the results from the full sample. Therefore, one can conclude that the growth rate of salary has a statistically significant negative effect on the probability of turnover in both samples. Second, in order to examine whether

bonus recipients and non-recipients are any different towards their propensities to turnover, I reproduce Table 2.9 separately for the two sub-groups. The pooled logits indicate that these workers in these subgroups are very similar in terms of their turnover behavior. However, the FE logits estimated on the subsample of non-recipients are not informative since there are very few observations to estimate these models.

To examine the effect of bonus payments on turnover, I estimate several specifications of equation (2.6). The results from pooled and FE logits are displayed in Tables 2.10 and 2.11, respectively. Before looking at how the size of bonus payments are related to turnover, I first test whether earning a bonus in the current period affects turnover. The results in column 1 (in both pooled and FE logits) show that workers who earned a bonus in the current period are less likely to turnover when the level of salary is held constant. This is true even in our richest specification in which we control for the worker's performance and promotion prospects. This result suggests that bonuses can provide additional information in understanding the turnover.

To be consistent with the earlier approach, I first test the effect of bonus payments conditioned on the current salary level (columns 2 to 4 on Tables 2.10 and 2.11), and then I repeat the analysis replacing the current salary level with the growth rate of salary (columns 5 to 7 on Tables 2.10 and 2.11). The results from pooled logits indicate that the size of the bonus payment in the current period has a negative and statistically significant effect on the probability of turnover after controlling for the current salary level. Note that the negative effect of bonus payments persists

Table 2.10: The Effects of Salary and Bonuses on Turnover (Pooled Logits)

Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Log(salary)	0.151 [0.192]	0.14 [0.146]	0.35 [0.185]	0.162 [0.192]			
Δ Log(salary)					-5.545** [0.584]	-2.686** [0.689]	-2.351** [0.691]
Earned bonus	-0.192* [0.081]						
Log(bonus)		-0.0223** [0.0050]	-0.0153* [0.006]	-0.014* [0.006]	-0.0197** [0.005]	-0.0157* [0.006]	-0.0142* [0.006]
Level=2	0.318** [0.121]	0.149 [0.0965]	0.19 [0.117]	0.318** [0.121]	0.251* [0.111]	0.332** [0.127]	0.449** [0.132]
Level=3	0.439** [0.143]	0.183 [0.109]	0.251 [0.136]	0.437** [0.143]	0.427** [0.116]	0.479** [0.138]	0.625** [0.143]
Level=4	0.664** [0.197]	0.262 [0.148]	0.411* [0.185]	0.662** [0.197]	0.650** [0.127]	0.801** [0.154]	0.941** [0.158]
Level=5	0.414 [0.453]	-0.121 [0.296]	-0.053 [0.439]	0.415 [0.453]	0.316 [0.249]	0.573 [0.385]	0.817* [0.389]
Rating=2	0.483** [0.0913]		0.514** [0.0905]	0.483** [0.0913]		0.405** [0.0975]	0.390** [0.0978]
Rating=3	1.095** [0.115]		1.164** [0.113]	1.096** [0.115]		1.013** [0.124]	0.978** [0.124]
Rating=4	1.762** [0.254]		1.872** [0.252]	1.764** [0.254]		1.606** [0.263]	1.559** [0.263]
Tenure at level=2	0.134 [0.106]			0.135 [0.106]			0.114 [0.116]
Tenure at level=3	0.259* [0.130]			0.260* [0.130]			0.248 [0.135]
Tenure at level=4	0.511** [0.158]			0.512** [0.158]			0.501** [0.160]
Tenure at level \geq 5	0.581** [0.162]			0.582** [0.162]			0.591** [0.162]
N(worker-yrs)	8,628	12,746	8,628	8,628	11,492	8,152	8,152
Log-likelihood	-2848	-4330	-2856	-2848	-3755	-2647	-2638
Pseudo-R ²	0.063	0.037	0.060	0.063	0.049	0.062	0.065
AIC	5758	8707	5766	5758	7557	5347	5338
BIC	5977	8886	5956	5977	7734	5536	5555

Table 2.11: The Effects of Salary and Bonuses on Turnover (Fixed-Effects Logits)

Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Log(salary)	39.07**	39.03**	52.24**	60.09**			
	[2.217]	[2.215]	[4.620]	[7.239]			
Δ Log(salary)					-5.986**	-3.904**	-2.724
					[0.990]	[1.476]	[2.056]
Earned bonus	-0.969**						
	[0.202]						
Log(bonus)		-0.0717**	-0.045	-0.0915*	-0.0696**	-0.0545**	-0.0559**
		[0.015]	[0.027]	[0.040]	[0.010]	[0.013]	[0.018]
Level=2	3.817**	3.810**	4.525	8.369**	4.503**	4.443**	14.04**
	[1.304]	[1.305]	[3.003]	[2.114]	[1.017]	[1.084]	[1.737]
Level=3	6.021**	6.029**	6.692	13.43**	9.327**	8.946**	25.37**
	[1.911]	[1.921]	[3.693]	[2.864]	[1.437]	[1.498]	[2.762]
Level=4	7.665**	7.673**	20.33	38.72	14.29**	26.58	52.64
	[2.426]	[2.428]	[1,450]	[8,074]	[1.772]	[563.3]	[925.9]
Level=5	13.26	13.27	39.42	63.26	17.05**	43.46	83.21
	[35.05]	[34.95]	[86,991]	[19,268]	[2.114]	[3,045]	[6,161]
Rating=2			0.911*	0.496		0.847**	0.456
			[0.452]	[0.635]		[0.221]	[0.323]
Rating=3			3.491**	2.770**		2.116**	1.201**
			[0.545]	[0.758]		[0.297]	[0.428]
Rating=4			5.327**	4.446**		2.204**	1.281
			[0.749]	[0.977]		[0.500]	[0.682]
Tenure at level=2				1.343*			2.816**
				[0.603]			[0.485]
Tenure at level=3				4.321**			5.898**
				[0.876]			[0.759]
Tenure at level=4				7.801**			9.296**
				[1.243]			[1.042]
Tenure at level \geq 5				11.60**			12.97**
				[1.669]			[1.321]
N(worker-yrs)	3,269	3,269	1,669	1,669	2,920	1,561	1,561
N(workers)	984	984	584	584	874	544	544
Log-likelihood	-394	-394.2	-137.3	-78.24	-759.2	-381.6	-184.7
Pseudo-R ²	0.643	0.643	0.764	0.865	0.227	0.299	0.66
AIC	800	800	292	182	1530	781	395
BIC	836	836	341	252	1566	829	464

after fixed effects are taken into account. Particularly, the estimated negative effect decreases in absolute value in pooled logits, whereas the effect peaks in column 4 in which the worker's performance and promotions prospects are controlled for in FE logits. Consistent with the earlier results, the level of salary has no significant effect on the probability of turnover when data are pooled over time, whereas it has a statistically significant and positive effect on turnover in FE logits.

When we include both the growth rate of salary and the bonus payment in our specification, results are consistent with the hypothesis that both of these variables have negative effects on turnover. A comparison of the point estimates for bonus payments across specifications leads to the following conclusions. First, bonus payments have a negative and significant effect on the probability of turnover in both pooled and FE logits. Second, similar to point estimates for the growth rate of salary, the point estimates for bonus payments also slightly decrease when we control for performance ratings and tenure at the current job level. Overall, the negative effects of both the growth rate of salary and bonus payments are robust to model specification.

As indicated, one of the goals of the present study is to show that using bonus payments along with salaries is a better empirical approach in analyzing turnover than using total compensation. To this end, I compare the results from models in which the total compensation is employed to measure the pecuniary benefits of the job to the results when salaries and bonus payments are included separately in the model.

Replacing salary with total compensation, I estimate all specifications reported in

Table 2.9 and report the results in Table 2.12. Overall, the results indicate that the effect of total compensation on turnover has similar patterns with the effect of salary on turnover. Similar to the level of salary, the effect of the level of total compensation on turnover is either insignificant (in pooled logits), or statistically significant and positive (in FE logits). Both pooled and FE logits show that the growth rate of total compensation has a statistically significant negative effect on the probability of turnover. In addition, the estimated effect declines when we account for the worker's performance and his future promotion possibilities. Indeed, FE logits indicate that the effect of the growth rate of total compensation on turnover vanishes when we control both for performance and future promotions (see column 6).

Comparing the results of the analysis when the pay variable is total compensation to those when both salaries and bonus payments are included in the estimation suggests that the latter approach is preferable in analyzing turnover. First of all, note that the two models, one with total compensation and the other with salaries and bonuses, are non-nested in the sense that one model is not a special case of the other. Therefore, I will make use of log-likelihood criteria with degrees of freedom adjustment in order to compare the goodness of fits of the two models. To this end, I will employ the Akaike information criterion (AIC) and the Bayesian information criterion (BIC).³² According to these criteria, the model with lower AIC (or BIC) is preferable since it has a better fit than the other model after controlling for the number of parameters.

³²AIC= $-2\ln L+2q$ and BIC= $-2\ln L+(\ln N)q$, where L denotes the log-likelihood value and q is the number of parameters estimated. Note that the penalty for the model size is larger in the BIC.

Table 2.12: The Effect of Total Compensation on Turnover

Variables	A. Pooled Logits						B. Fixed-Effects Logits					
	[1]	[2]	[3]	[4]	[5]	[6]	[1]	[2]	[3]	[4]	[5]	[6]
Log(comp)	0.0296 [0.133]	0.229 [0.166]	0.0642 [0.172]				10.53** [0.747]	11.35** [1.124]	6.948** [1.292]			
Δ Log(comp)				-2.545** [0.342]	-1.645** [0.418]	-1.471** [0.421]				-2.350** [0.464]	-1.534* [0.685]	0.671 [0.978]
Level=2	0.151 [0.0963]	0.197* [0.117]	0.330** [0.121]	0.250* [0.112]	0.338** [0.127]	0.461** [0.133]	3.687** [1.014]	3.533** [1.050]	13.57** [1.859]	4.204** [1.012]	4.317** [1.066]	14.22** [1.776]
Level=3	0.161 [0.108]	0.250* [0.134]	0.444** [0.142]	0.372** [0.117]	0.461** [0.138]	0.616** [0.143]	7.048** [1.434]	6.571** [1.478]	24.05** [2.922]	8.630** [1.428]	8.575** [1.480]	25.61** [2.818]
Level=4	0.254 [0.146]	0.439* [0.181]	0.695** [0.192]	0.468** [0.126]	0.721** [0.154]	0.877** [0.158]	10.49** [1.761]	21.46 [376.5]	51.71 [1.524]	13.16** [1.757]	26.63 [711.7]	52.31 [627.2]
Level=5	-0.0631 [0.294]	0.00924 [0.436]	0.493 [0.449]	0.111 [0.253]	0.528 [0.383]	0.793* [0.388]	13.14** [2.244]	37.98 [1.708]	82.73 [14.097]	27.54 [386.8]	44.22 [3.649]	81.94 [3.997]
Rating=2		0.537** [0.0900]	0.501** [0.0909]		0.458** [0.0966]	0.436** [0.0969]	1.119** [0.236]		0.714* [0.326]	0.966** [0.219]		0.677* [0.317]
Rating=3		1.224** [0.111]	1.142** [0.113]		1.123** [0.120]	1.073** [0.120]	2.940** [0.313]		1.949** [0.430]	2.359** [0.289]		1.598** [0.415]
Rating=4		1.931** [0.251]	1.810** [0.253]		1.774** [0.257]	1.704** [0.258]	3.611** [0.521]		2.414** [0.694]	2.567** [0.486]		1.847** [0.666]
Tenure at level=2			0.139 [0.106]			0.125 [0.115]			2.358** [0.481]			2.655** [0.478]
Tenure at level=3			0.278* [0.130]			0.253* [0.134]			5.813** [0.816]			5.806** [0.755]
Tenure at level=4			0.536** [0.157]			0.516** [0.159]			9.097** [1.086]			9.269** [1.042]
Tenure at level \geq 5			0.624** [0.161]			0.611** [0.162]			12.71** [1.361]			13.03** [1.322]
N(worker-yrs)	12,746	8,628	8,628	10,894	8,112	8,112	3,269	1,669	1,669	2,646	1,550	1,550
N(workers)	4,006	3,355	3,355	3,475	3,107	3,107	984	584	584	823	540	540
Log-likelihood	-4340	-2860	-2851	-3597	-2630	-2621	-718.7	-328.5	-176.6	-733.5	-389.4	-188
Pseudo-R ²	0.0345	0.0589	0.0619	0.0423	0.0607	0.0639	0.348	0.434	0.696	0.185	0.279	0.652
AIC	8726	5772	5762	7237	5309	5299	1447	672	377	1476	794	400
BIC	8898	5956	5974	7397	5484	5502	1447	716	442	1506	837	464

In comparing the models, I focus on the richest specification in which performance ratings and tenure at the current job level, in addition to other control variables common in all specifications, are included. Comparison across pooled logits gives mixed results. For example, according to the results reported in column 4 in Table 2.10 and column 3 in Table 2.12, the AIC favors the model in which the levels of salaries and bonuses enter separately into the estimating equation to the model with the level of total compensation (5758 vs. 5762), whereas the BIC gives the opposite result (5977 vs. 5974). For the growth rates of pay variables, on the other hand, both criteria favor the model with total compensation (see column 7 in Table 2.10 and column 6 on Panel A in Table 2.12). However, this finding is not robust to model specification. Specifically, the BIC favors the model with salaries and bonuses when performance ratings are controlled for (see column 6 in Table 2.10 and column 5 on Panel A in Table 2.12).

The comparison of the FE logits, on the other hand, gives more uniform results. Accordingly, in all specifications both the AIC and BIC favor the model in which the levels of salaries and bonuses enter separately (see columns 2-4 in Table 2.11 and columns 1-3 on Panel B in Table 2.12). For the specifications in which the growth rates of pay variables are used, a similar pattern is observed. Specifically, comparing the results in column 7 in Table 2.11 to those in column 6 on Panel B in Table 2.12 reveals that the AIC favors the model with salaries and bonuses, whereas the BIC does not discriminate among the models.

Besides the goodness of fit, if one is interested in controlling for the pecuniary re-

turns to employment, one should be cautious in model selection. We observe that the estimated effects of salaries are larger, in absolute terms, than total compensation, and that bonus payments have significant effect on turnover. These results follow from the fact that pay variables have different dynamics since their associations with future compensation are different. Therefore, the evidence based on the firm-level data suggests that the empirical approach that treats salaries and bonuses as different forms of pay variables is a better empirical approach in analyzing turnover.

2.5.2 Analysis Based on the PSID Sample

In this section, I examine the effects of pay variables on turnover using the sample drawn from the PSID. As discussed earlier, this analysis enables us to account for firms' heterogeneity in personnel policies, and to examine if the aforementioned findings differ for layoffs and quits. The shortcoming of this sample is that it does not include any performance measures such as supervisor ratings, and workers' positions within the firm's hierarchy. Therefore, I will employ workers characteristics as control variables. Specifically, each specification includes control variables for the worker's education, age, tenure at the firm, and marital status.

Following the approach taken in the first part of the empirical analysis, I estimate logit models for different specifications. Table 2.13 reports the results for specifications under which salaries and bonus payments enter separately into the estimating equation. In columns 1 and 4, the dependent variable indicates whether the worker

separates or not, without specifying the party that initiated the separation. Therefore, these results are comparable to the earlier analysis in the paper. In columns 2 and 4, the same specifications are estimated for the subsample of stayers and quitters, while columns 3 and 6 display the results for the subsample of stayers and laid-off workers.

Before interpreting the results concerning the pay variables, let us examine how some of the explanatory variables are related to turnover. The results show that workers with either a college or a graduate degree are less likely to separate than workers with a high school degree or workers who have not completed high school. This empirical pattern is the same in layoffs and quits. The worker's tenure at the firm has a negative effect on turnover in all specifications. This finding is consistent with job search theories implying that employments with longer tenure are more likely to be a good firm-worker match (e.g., MacDonald, 1988). Finally, the results indicate that married workers are less likely to turnover. One possible explanation for this finding is that since the cost of turnover is higher for married workers, they are less likely to turnover.

Note that the firm-level data analyzed in the previous section differs from the PSID sample in terms of job types and worker characteristics. As indicated, the firm-level data include information regarding workers employed in managerial positions, whereas the PSID sample includes a variety of blue- and white-collar jobs. Another major difference between the two datasets relates to workers' education levels. Specifically, about 68 percent of workers in the firm-level data have either a

Table 2.13: The Effects of Salary and Bonus Payments on Turnover (PSID Sample)

	All	Quits	Layoffs	All	Quits	Layoffs
VARIABLES	[1]	[2]	[3]	[4]	[5]	[6]
Log(salary)	-0.530** [0.0357]	-0.574** [0.0499]	-0.479** [0.0426]			
Δ Log(salary)				-0.268** [0.0531]	-0.246** [0.0899]	-0.200** [0.0695]
Log(bonus)	-0.0497* [0.0198]	-0.0475 [0.0390]	-0.0470* [0.0230]	-0.041 [0.0226]	-0.0614 [0.0465]	-0.0385 [0.0261]
High school or GED	0.144 [0.0755]	-0.0967 [0.136]	0.356** [0.0910]	0.0644 [0.103]	-0.144 [0.187]	0.251* [0.122]
College	-0.320** [0.110]	-0.796** [0.230]	-0.313* [0.134]	-0.617** [0.142]	-1.007** [0.299]	-0.596** [0.170]
Graduate	-0.646* [0.257]	-1.001 [0.592]	-0.840* [0.331]	-0.995** [0.307]	-1.36 [0.726]	-1.384** [0.425]
Age	0.0803** [0.0195]	0.0173 [0.0333]	0.102** [0.0240]	0.0487 [0.0272]	-0.00151 [0.0476]	0.0547 [0.0323]
Age ² /100	-0.0900** [0.0235]	-0.0272 [0.0407]	-0.113** [0.0288]	-0.0511 [0.0322]	0.00311 [0.0567]	-0.0562 [0.0380]
Married	-0.449** [0.0752]	-0.616** [0.140]	-0.438** [0.0896]	-0.602** [0.101]	-0.791** [0.188]	-0.608** [0.119]
Tenure	-0.144** [0.0148]	-0.167** [0.0299]	-0.128** [0.0181]	-0.145** [0.0194]	-0.207** [0.0368]	-0.119** [0.0238]
Tenure ² /100	0.317** [0.0536]	0.350** [0.111]	0.248** [0.0700]	0.292** [0.0716]	0.479** [0.120]	0.184 [0.0954]
N(worker-yrs)	15,854	12,367	15,091	8,130	7,152	7,734
Log-likelihood	-3135	-1102	-2321	-1748	-613.9	-1319
Pseudo-R ²	0.15	0.144	0.142	0.0916	0.0991	0.102
AIC	6301	2233	4672	3523	1254	2663
BIC	6416	2337	4786	3614	1343	2754

college degree or a graduate degree, whereas only 26 percent of workers in the PSID sample have those degrees.³³

³³An ideal approach to compare the results from the two datasets is to focus on a PSID subsample of workers with managerial jobs in the financial services industry. However, since this restriction leaves few observations in our working sample, the current paper does not include an analysis on

The results regarding the effect of salaries are the same for layoffs and quits. Specifically, both the level and the growth rate of salary have statistically significant negative effects on turnover. We observe that the negative effect of salary level is larger (in absolute value) on quits. The same pattern is observed for the growth rate of salary. This finding suggests that the worker's salary (in terms of both levels and growth rates) plays a more important role in determining a worker-initiated separation than it does in determining a firm-initiated separation. Note that the negative effect of the salary level on turnover is consistent with search theories discussed earlier. However, this result is not in line with the firm-level analysis in which we found either positive or insignificant effects of salary level on turnover.

The results regarding bonus payments are mixed. Specifically, the size of bonus payments has a statistically significant (at the 5 percent level) negative effect on turnover after controlling for the level of salary (see column 1). The negative effect is smaller, but still statistically significant (at the 10 percent level) when we control for the growth rate of salary (see column 4). When I separately examine layoffs and quits, the point estimates are still negative in all specifications. However, it is statistically significant only for layoffs after controlling for the level of salary. In other cases, even if the estimated effect is negative the standard errors are too large to make a statistical inference. One potential explanation for the finding that bonuses have a significant effect on layoffs, but not on quits, is that bonus payments possess information about the worker's current performance, which plays a crucial role in the layoff decision.

this subsample.

Table 2.14: The Effect of Total Compensation on Turnover (PSID Sample)

	All	Quits	Layoffs	All	Quits	Layoffs
VARIABLES	[1]	[2]	[3]	[4]	[5]	[6]
Log(compensation)	-0.535** [0.0350]	-0.576** [0.0492]	-0.487** [0.0418]			
Δ Log(compensation)				-0.285** [0.0519]	-0.248** [0.0888]	-0.231** [0.0672]
High school or GED	0.150* [0.0754]	-0.0946 [0.136]	0.364** [0.0909]	0.0657 [0.103]	-0.153 [0.187]	0.257* [0.122]
College	-0.346** [0.110]	-0.824** [0.230]	-0.334* [0.134]	-0.641** [0.142]	-1.047** [0.298]	-0.612** [0.170]
Graduate	-0.662* [0.257]	-1.024 [0.592]	-0.848* [0.331]	-1.025** [0.306]	-1.413 [0.725]	-1.401** [0.425]
Age	0.0803** [0.0195]	0.0173 [0.0332]	0.103** [0.0240]	0.0501 [0.0272]	-0.0012 [0.0475]	0.0573* [0.0323]
Age ² /100	-0.0894** [0.0235]	-0.0265 [0.0406]	-0.113** [0.0288]	-0.0521 [0.0322]	0.00332 [0.0565]	-0.0585 [0.0380]
Married	-0.457** [0.0751]	-0.623** [0.140]	-0.446** [0.0895]	-0.614** [0.101]	-0.812** [0.187]	-0.616** [0.119]
Tenure	-0.147** [0.0147]	-0.170** [0.0297]	-0.129** [0.0180]	-0.146** [0.0193]	-0.211** [0.0364]	-0.119** [0.0238]
Tenure ² /100	0.319** [0.0532]	0.354** [0.110]	0.249** [0.0696]	0.291** [0.0714]	0.484** [0.118]	0.178 [0.0955]
N(worker-yrs)	15,926	12,431	15,159	8,194	7,212	7,793
Log-likelihood	-3144	-1104	-2327	-1753	-618.3	-1321
Pseudo-R ²	0.149	0.144	0.142	0.0922	0.0994	0.102
AIC	6316	2235	4682	3531	1261	2665
BIC	6424	2331	4789	3615	1343	2749

In Table 2.14, I used the worker's total compensation instead of using salaries and bonuses separately, and re-estimated all specifications in Table 2.13. The effect of total compensation is qualitatively the same as that of salaries; both the level and the growth rate of total compensation have negative and statistically significant (at the 1 percent level) effect on turnover. Indeed, the point estimates for total compen-

sation are only slightly larger (in absolute terms) than that of salaries. In terms of differences between layoffs and quits, we observe the same pattern. Accordingly, the worker's compensation has a larger impact on the probability of quits than it has on the probability of layoffs. As the discussion in the previous part indicates, one way to compare non-nested models' goodness of fit is to use information criteria. To this end, Tables 2.13 and 2.14 report the values of AIC and BIC for each specification. We observe that both the AIC and BIC are lower when I estimate the effects of salaries and bonuses separately (as in Table 2.13) rather than estimating the effect of total compensation (as in Table 2.14).

Overall, the analysis based on the PSID sample suggests that using salaries and bonuses separately in analyzing turnover is a better empirical approach. First, bonus payments have a significant negative effect on turnover after controlling for salaries. Second, comparing the models in terms of goodness of fit indicates that the model in which the effects of salaries and bonuses are estimated separately is favored over the model that uses total compensation to measure pecuniary benefits of the job.

2.6 Summary and Concluding Remarks

This paper examines the effect of pay variables on turnover. Using the wealth maximization model to motivate testable predictions, I argue that the current values of pay variables can relate to turnover to the extent they are associated with the worker's future compensation. The main theoretical argument that motivates the

empirical prediction analyzed in the paper is that the probability of separation is negatively related to the worker's future earnings at the firm. I find supporting evidence for this general hypothesis.

The empirical analysis yields several results. First, the effect of the growth rate of salary is negative on turnover, whereas the results regarding the effect of salary level are mixed. Second, both having earned a bonus in the current period and the size of the bonus have negative effects on turnover. Third, total compensation and salary have qualitatively similar effects on turnover, while the magnitudes of the effects differ. Fourth, the negative effects of pay variables are more evident on quits than they are on layoffs. This finding applies to both salaries and bonus payments. Finally, the results suggest that using a specification that treats salaries and bonus payments separately yields a better fit than using a specification with total compensation.

Overall, the empirical evidence indicates the importance of making use of all information regarding the pecuniary benefits of a job. As demonstrated, the estimated effects of total compensation differ from salaries. Hence, the researcher, who aims to control for the worker's compensation at the current job in order to obtain unbiased estimates for other variables of interest, should be prudent in determining with which variables to measure the pecuniary returns to employment at the current job.

The results of the paper also point out some directions for future research. For example, the firm-level analysis and the analysis based on the PSID sample yield contradictory results concerning the effect of salary levels on turnover. This result may be driven by idiosyncrasies of the firm studied here. However, if this result

is more general, then understanding the dynamics that generate these conflicting results is important for the generalizability of results based on firm-level data. In addition, developing a formal theoretical model that focuses on the turnover effects of bonus payments (or performance-pay contracts) may be a fruitful research avenue. As discussed, earlier literature focuses on bonus contracts in analyzing efficiency of separations. However, it is plausible to think that bonus payments, similar to salaries, provide information about the match quality between the firm and the worker. Therefore, they are likely to affect turnover decisions.

CHAPTER 3

EMPLOYEE REFERRALS AS A SCREENING DEVICE

3.1 Introduction

Firms frequently hire new people through referrals from current employees. For example, Marsden (2001) finds that more than one third of all establishments surveyed in the 1991 National Organizations Survey (NOS) often used referrals when announcing job openings.¹ Existing literature has identified several ways by which firms and job applicants find employee referrals beneficial. For example, employee referrals reduce search costs (Calvo-Armengol and Jackson, 2004); firms enjoy lower monitoring costs due to peer pressure imposed on workers hired through referrals (Kugler, 2003); firms use referrals as a screening mechanism to reduce asymmetric information inherent in the hiring process (Montgomery, 1991; Simon and Warner, 1992). The screening function of employee referrals is the subject of the present paper.

The idea that employee referrals are used as a screening device dates back to the early work of Rees (1966). The basic premise of this idea is that referrals provide information about the job applicant's productivity that the firm otherwise would not have. The formalization of this mechanism is developed within two separate approaches. Montgomery (1991) assumes that the referrer's productivity is positively correlated with that of the job applicant due to assortative matching between in-

¹See Ioannides and Loury (2004) and Topa (2011) for extensive surveys of the literature.

dividuals in social networks, while Simon and Warner (1992) assume that referrals reduce the uncertainty regarding the productivity of the job applicant. Note that in Montgomery's approach, the employee's ability, which has been revealed to the current employer over time, is informative by itself about the referral's ability. Hence, the employee referrals inherently provide information about the applicant's ability. On the other hand, Simon and Warner (1992) assume that the employee truthfully transmits her private information about the job applicant's ability. Note that an important assumption in both models is that the incentives of the current employee are perfectly aligned with those of the firm in hiring decisions.

This paper points out two mechanisms that could potentially lead to a conflict of interest between the firm and the current employee in the referral process. First, I examine how social connections affect employee referrals. Specifically, I allow the employee to feel altruistic toward the job applicant where the degree of altruism depends on the strength of the social connection between himself and the applicant, and discuss how this alters the employee's referral decision. Second, I examine how the employee's referral decision is affected by his promotion prospects. Empirical evidence indicates that promotions are associated with large wage increases (e.g., McCue, 1996). Therefore, the employee will be concerned about his promotion prospects when referring an applicant. In particular, if referring an applicant reduces his chances of promotion then he may choose not to refer the applicant even though it is efficient to do so. To examine under what conditions these mechanisms distort referral recruitment, I develop a theoretical model in which the firm solicits a referral from a current employee, who draws a job applicant from his social network and

privately observes the applicant's ability and the strength of the social connection between himself and the applicant. The profit maximizing firm then decides whether to hire a referred applicant or an applicant who has not been referred by a current employee.

I investigate the employee's referral decision under three scenarios. First, the firm remunerates a fixed payment to the employee when his referral is hired. Referrals do not provide screening of job applicants in this case since the employee's decision is based on his social connection to the applicant, rather than on the applicant's ability. Therefore, employees refer applicants with whom they have a close social connection when they are eligible to earn a fixed payment. Next, I consider the situation in which the employee is eligible to earn a bonus which is contingent on the referral's performance. Unlike the fixed-payments case, the firm is able to elicit information about job applicants' ability since bonuses provide employees with an incentive to refer higher ability applicants. Hence, employee referrals serve a screening function only when the firm provides employees with proper incentives to make referrals.

Finally, I use the tournament framework to incorporate promotion incentives into the model with referral bonuses. With some positive probability the employee competes against his own referral, rather than against a coworker whose ability is unknown to him, to earn the promotion prize. Since the employee's probability of earning the promotion decreases with the referral's ability, promotion concerns create a conflict of interest between the firm and the employee concerning referral recruitment. Whether this tension eliminates the screening function of referrals depends

on the relative weights of incentives and disincentives provided by bonuses and promotions, respectively. If the incentives provided by referral bonuses dominate the disincentives induced by the employee's promotion concerns, referrals continue to serve a screening device. Otherwise, the employee behaves in an opportunistic fashion and refers less able applicants who do not damage his promotion prospects. In that case, the firm cannot screen high ability applicants using employee referrals.

There is empirical evidence suggesting that there is a conflict of interest between the firm and the current employee during the referral process. Beaman and Magruder (2011) conducted a social experiment in which they randomized the monetary rewards that the employees could earn by referring another worker in their social network. They find that employees refer highly skilled applicants only when they are offered a bonus that is tied to the referral's performance. When they are offered a fixed payment, which is not contingent on the referral's performance, they are more likely to refer a relative or a friend. In a related study, Fafchamps and Moradi (2011) examined historical data from the Ghana Colonial Army in which current recruits were eligible for fixed payments when they make a referral. They find that new recruits hired through referrals are not associated with higher unobserved qualities than new recruits hired through other channels. Note that the findings of these studies support the result of the current paper that employee referrals are useful for screening purposes only when the employee is provided with incentives to refer high-ability applicants.

The rest of the paper is organized as follows. Section 2 describes the related theo-

retical literature. Section 3 presents the model; subsections consider fixed payments for referrals, bonuses and the effect of promotions in turn. Section 4 concludes the paper.

3.2 Related Theoretical Literature

In most of the existing literature, the idea that employee referrals serve a screening function is examined under the assumption that there is no conflict of interest between the firm and employees concerning referrals. For example, Montgomery (1991) provides a framework to study the effect of social structure on wages and firms' profits. He argues that people's tendency to have social connections with people who have similar characteristics with themselves provides a rationale for the use of employee referrals. Accordingly, productive employees are more likely to refer productive applicants, thus applicants who are well connected (i.e., who have ties with productive employees) find jobs with higher wages and firms hiring through referrals earn positive profits. However, he assumes that the current employee's referral decision is nonstrategic in the sense that he does not make any cost-benefit analysis when deciding to refer an applicant. Building upon the job matching framework (Jovanovic, 1979), Simon and Warner (1992) show that workers hired through referrals earn higher starting wages, have longer tenure on the job, and experience lower wage growth than workers hired through other channels.² The assumption

²Dustmann, Glitz, and Schönberg (2011), and Brown, Setren, and Topa (2012) also use the job matching framework to derive testable predictions concerning how referrals' wages and tenure at the job differ from nonreferrals.

that drives their results, however, is that referrals provide information about the applicant's productivity that the firm otherwise would not have, thus they reduce the uncertainty about the quality of the match between the worker and the job. In other words, they implicitly assume that the incentives of current employees are perfectly aligned with those of the firm concerning referral recruitment.

In related work, Saloner (1985) considers how the competition among referees affects informativeness of their recommendations. In that setup, each referee is concerned about the quality of applicants he recommends as well as the number of them who have found a job through his recommendation. In equilibrium, even though each referee acts strategically, they transmit the private information about job applicants in a way that the firm would hire the same applicants if it had the same information as referees. However, Saloner explicitly assumes that the objectives of the referees are perfectly aligned with those of the user of referrals. Therefore, the strategic behavior of referees refers to how they optimize between the quantity and the quality of their referrals.

The paper is also related to the literature on favoritism in organizations. Firms frequently assign supervisors to monitor the performance of its employees. In this setting, the supervisor privately observes the worker's performance (or rather a signal of performance), and transmits his private information to the firm. The firm then determines the worker's compensation in accordance with the performance evaluation. This process is prone to some influence activities. For example, Prendergast and Topel (1996) argue that supervisors may favor some workers purely for exogenous

reasons, thus performance evaluations may be distorted in equilibrium.³ Fairburn and Malcomson (2001) consider the case in which the worker's performance evaluation determines whether he earns a bonus or not, and show that the worker has an incentive to bribe the supervisor in order to improve his performance evaluations. Even though the context considered in the current paper is not the same those discussed as the one considered in the current paper, the basic idea is similar; the firm attempts to elicit private information of its employees in order to maximize its profits, while the employee uses his private information for his own benefit.

Carmichael (1988) considers the idea that there might be a conflict of interest between a university and its current academic staff concerning new hires. Similar to the setting considered in the current paper, current employees have better information about job candidates' abilities than the university administration. Therefore, the administration asks its current employees to evaluate abilities of job candidates. Current employees are, however, concerned about their future employment at the university in the sense that the administration may fire them in order to make room for a candidate who has more research potential. Therefore, their incentives may not be aligned with those of the university in selecting the best candidates. Carmichael shows that "tenure-track" appointments can alleviate the problem as they ensure that the current researchers will not lose their jobs when they are outperformed by newly hired researchers. In the current paper, I focus on employees' concerns about their future career at the firm and social connections between employees and job

³Milgrom and Roberts (1988), and Milgrom (1988) discuss how employees may indulge in influence activities to improve their performance reports

candidates. In that sense, I consider different mechanisms that lead to a conflict of interest. Also, he assumes that current employees transmit a signal concerning the ability of a job candidate, while I allow them not to reveal their opinion of the job candidate's ability by choosing not to refer the applicant.

3.3 Model

In this section, I develop a theoretical model to examine the screening role of employee referrals when incentives of the firm are not perfectly aligned with those of current employees. To this end, I first develop a model in which the current employee earns a fixed payment when his referral is hired by the firm. Next, I replace fixed payments by referral bonuses, which are contingent on the referral's performance, and discuss the implications. Finally, I incorporate promotions into the model to examine under what conditions and in which direction their presence affects referral recruitment. All proofs are provided in the Appendix.

3.3.1 Referrals with Fixed Payments

I consider a single firm that has no market power in the labor market. Therefore, it can hire a new worker at the market wage and makes zero expected profits. Alternatively, the firm can fill a vacancy by hiring an applicant who is referred by a current employee. It chooses to do so only if it earns positive profits from hiring a referred

applicant. By assumption, the firm knows the ability levels of its employees, while it cannot observe a job applicant's ability.

Without loss of generality, let subscript i refer to a current employee, j refer to a job applicant who is referred by a current employee, and k refer to an anonymous applicant (i.e., who is not referred by a current employee). Each employee i draws an applicant j from his social network and privately observes her ability.⁴ The ability of workers, θ_l ($l \in \{i, j, k\}$), is uniformly distributed over the interval $[\theta_L, \theta_H]$ and $\hat{\theta}$ denotes the average ability level in the labor market. In addition to ability, the strength of the social connection between employee i and applicant j , denoted by σ_{ij} , is privately known by the employee. The term σ_{ij} can be interpreted as employee i 's altruism towards applicant j .⁵ Accordingly, applicant j is a close acquaintance of employee i ($\sigma_{ij} = \sigma_H$) with probability $1 - \rho$, while he is not ($\sigma_{ij} = \sigma_L$) with probability ρ . I assume $\sigma_H > \sigma_L \geq 0$ so that the employee has a greater bias in favor of a close acquaintance, and that realizations of θ_j and σ_{ij} are independent. After privately observing θ_j and σ_{ij} , the employee decides whether to refer the applicant to his current employer at a cost of $c > 0$. If the employee decides to make a referral, the firm matches the applicant with the current employee who has made the referral, but it can observe neither the applicant's ability nor the strength of their social connection. Otherwise, it cannot match applicants with any employees.⁶ The

⁴Drawing only one applicant is equivalent to drawing multiple applicants independently from the same distribution.

⁵Beaman and Magruder (2011) note that these payments could be interpreted as a reduction in future payments that i would otherwise have to make to applicant j due to risk sharing or other network-based arrangements.

⁶In other words, the firm cannot observe the relationship between a current employee and a job applicant when the employee decides not to refer the applicant.

employee receives a fixed payment $F > 0$ from the firm if his referral is hired at the end of the recruitment process.

Following Prendergast and Topel (1996), and Bandiera, Barankay, and Rasul (2009), I assume the employee's preferences are affected by his social connection to the referred applicant. Therefore, employee i 's utility if his referral j is hired by the firm is given by

$$U_i = w_i + F + \sigma_{ij} - c, \quad (3.1)$$

where w_i is the wage level, F is the payment from the firm, σ_{ij} measures, as discussed above, the social connection between the employee and the applicant, and c is the cost of referring the applicant. Note that employee i 's utility is simply equal to his wage w_i when he does not refer the applicant. The fixed payment F is assumed to be a monetary reward offered by the firm if the referral is hired.⁷ The crucial assumption, which will be relaxed in the next section, is that the payment of F is not contingent on the referral's performance.

If the firm decides to make an offer to referred applicant j , he compares the wage offer to his outside option and decides whether to accept the offer. As discussed, the firm is able to hire an anonymous applicant at the market wage. However, there is no certainty that the referred applicant will accept the firm's job offer. If he has a better alternative offer, he will decline the offer. To model the applicant's decision, I

⁷Alternatively, F could be the employee's non-monetary benefits from referring an applicant. Research in social psychology has shown that employees who make referrals will have increased organizational normative commitment and job satisfaction regardless of whether they have intrinsic or extrinsic motivation to make referrals (Shinnar, Young, and Meana, 2004). Hence, it is plausible to assume that the employee will enjoy some "benefits" when the referred applicant is hired by his current employer.

assume he privately draws a random utility shock κ_j , which is uniformly distributed over the interval $[-\bar{\kappa}, \bar{\kappa}]$.⁸ Applicant j 's utility is then given by

$$U_j = \max \{W^R, W^M + \kappa_j\}, \quad (3.2)$$

where W^R and W^M denote the referral wage and the market wage, respectively. Therefore, the applicant will accept the firm's job offer if $W^R > W^M + \kappa_j$. Note that the applicant may accept a wage offer which is lower than the market wage when the realized value of κ_j is negative.

For simplicity, I assume that output is only a function of the worker's ability. The output of a worker is then given by $y_l = \theta_l + \epsilon_l$, where a mean-zero error term, ϵ_l , is independently and identically distributed across workers with unimodal, symmetric and differentiable density $f(\epsilon)$. Note that this production technology disregards any spillover effects between socially connected workers. Therefore, the firm's expected profits from hiring a worker is given by

$$\Pi = \max \{E[\theta_j | \text{referred by } i] - W^R - F, 0\} \quad (3.3)$$

Note that the firm's expected profits from hiring a referral is equal to the referral's expected ability minus the referral's wage and the fixed payment paid to the referrer, whereas the firm makes zero expected profits from hiring an anonymous worker. This implies that the firm hires a referral only if it earns positive rents.

The timing of the game is as follows. The firm solicits a referral from its current

⁸For simplicity, the realization of κ_j is assumed to be independent of the applicant's ability θ_j . A more plausible assumption, which would not alter the main results, is that more able workers have better alternative offer, i.e., κ_j and θ_j are positively correlated.

employees. Each employee draws an applicant from his social network, and decides whether to refer the applicant to the firm after privately observing the applicant's ability as well as the strength of their social connection. If an applicant is referred by a current employee, the firm updates its beliefs regarding the ability of the applicant, otherwise all applicants look *ex-ante* identical to the firm. The firm makes a wage offer to the referred applicant if it decides to hire the referral, otherwise it hires an anonymous applicant from the labor market. The referred applicant privately draws a utility shock, and then decides whether to accept the firm's offer.

Note that in this setup the employee is not allowed to choose an applicant from his social network when making a referral decision. Rather, he decides whether to refer a randomly drawn applicant. Therefore, the optimal strategy of the current employee is to refer the applicant as long as the cost of referring does not exceed the benefits. The firm, on the other hand, updates its belief regarding the applicant's ability if she is referred by a current employee. If the referred applicant's ability is sufficiently high to offset the cost of the fixed payment F , the firm makes a wage offer to hire the referred applicant. Otherwise, it is optimal to hire an anonymous worker at the market wage.

To formalize the employee's decision, let us write the returns from referring applicant j as follows

$$\phi(F, \sigma_{ij}, c) = F + \sigma_{ij} - c. \tag{3.4}$$

Since the employee's current wage level w_i is independent of the referral process, it does not enter function $\phi(\cdot)$. It is optimal for the employee to refer the applicant

as long as $\phi(.) \geq 0$.⁹ The employee's decision depends on the strength of his social connection with the applicant, but it is independent of the applicant's ability. For example, if $\sigma_H > c - F > \sigma_L$, the net benefits of referring an applicant is nonnegative only if the employee has a close social connection with the applicant. As a result, the employee will refer only close acquaintances from his social network. In this case, employee referrals are not informative about the applicant's ability since the employee's decision is based on the strength of his social connection to the applicant rather than on the applicant's ability. Note that applicants self-select in terms of their social connections to current employees since only close acquaintances of current employees are referred. However, this has no value to the firm since we disregard situations in which employing socially connected workers increases the firm's profits.¹⁰

Consequently, the expected ability of a referral is equal to that of an anonymous applicant in equilibrium regardless of what type of social connections induces referrals. In other words, employee referrals do not serve a screening function in this setup. The firm finds it optimal to hire an anonymous applicant rather than the referred applicant since it has to reimburse a fixed payment of F to the referrer if it hires through a referral. Anticipating that his referral will not be hired by the firm,

⁹If returns from referring an applicant is zero, the employee is indifferent between referring and not referring the applicant. I assume throughout that the employee refers the applicant in this case.

¹⁰Employing socially connected workers may be beneficial to the firm in a number of ways. For example, the referrers could help the firm monitor newly hired workers on which they can exert peer pressure (Kugler, 2003); or complementarity in production between socially connected workers may increase the overall performance of the firm (Bandiera, Barankay, and Rasul, 2009). Examining data from a single firm, Bandiera, Barankay, and Rasul (2009) find that social connections increase the performance of connected workers, but they reduce the firm's overall performance.

the employee does not refer any applicants in equilibrium since he cannot make up for the cost of referring, c .

Proposition 3 *In equilibrium, the employee does not refer any applicants, and the firm hires an anonymous worker at the market wage.*

There is empirical evidence consistent with the result that fixed payments do not incentivize current employees to refer applicants whose unobserved qualities are better than those of an unreferred applicant. Fafchamps and Moradi (2011) examined data from the Ghanaian colonial army over the 1908-1923 period. In their setting, the army offered a financial reward to the current officers who bring a new recruit. Whether they used referrals for screening purposes or to reduce recruitment costs is not clear. However, the longitudinal nature of the data allows them to test whether referrals serve a screening function. They find that even though referred recruits had better observed characteristics at the time of hiring, it is revealed in the long run that their unobserved characteristics were of lower quality. Specifically, referred recruits are shown to be more likely to desert or to be dismissed as inefficient. These findings, the authors suggest, might explain why the colonial army stopped offering financial incentives for referrals after World War I.

3.3.2 Referral Bonuses

In this section, I introduce referral bonuses that the employee earns if his referral meets a certain output-based criteria determined by the firm. Specifically, the firm sets an output level \tilde{q} so that employee i earns a bonus of B if his referral j produces more than the output level \tilde{q} .¹¹ Therefore, the probability employee i earns the bonus is given by $\text{prob}(y_j > \tilde{q}) = \text{prob}(\epsilon_j > \tilde{q} - \theta_j) = 1 - F(\tilde{q} - \theta_j)$. We can rewrite employee i 's expected returns from referring applicant j as follows

$$\phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B) = \sigma_{ij} - c + [1 - F(\tilde{q} - \theta_j)] B. \quad (3.5)$$

It is easy to see that the expected returns from referring are increasing with the size of the bonus B and decreasing with the threshold output level \tilde{q} . Since the payment of bonuses are contingent on the referral's performance, the expected returns increase with the referral's ability (i.e., $\frac{\partial \phi(\cdot)}{\partial \theta_j} > 0$). Therefore, unlike fixed payments, referral bonuses provide an incentive for the employee to refer higher ability applicants.

The employee's optimal strategy is the same as before; he refers the applicant as long as the expected returns are non-negative. Since the expected returns are increasing with the applicant's ability, there exists a cutoff ability level such that the employee refers the applicant as long as she is of higher ability than the cutoff. Let $\tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})$ denote the lowest-ability applicant that employee i refers when his social connection is σ_{ij} , and the output threshold to earn the bonus is \tilde{q} . The ability

¹¹The employee's referral decision is affected by the size of the expected bonus payment. Therefore, the value of bonus B could also be determined endogenously. However, I do not consider this possibility since it does not provide additional insight.

cutoff depends on the social connection between the employee and the applicant since other things equal the employee enjoys higher benefits from referring a close acquaintance.¹² It is possible to characterize the cutoff using the following condition

$$\phi(\sigma_{ij}, c, \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q}), \tilde{q}, B) = 0, \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\}. \quad (3.6)$$

Note that the cutoff increases with the value of \tilde{q} . The reason is that as the firm requires a higher level of output to reimburse the bonus, the employee needs to refer applicants of higher ability in order to make up for the decrease in the expected returns from referring. Unlike the fixed payments, the firm is able to affect the expected ability of a referral using bonuses. However, this does not come without costs; as the firm sets a higher value of \tilde{q} , the employee becomes less likely to refer an applicant since it is less likely to draw an applicant whose ability is higher than the cutoff. Thus, the firm faces a trade-off between the quality and the quantity of employee referrals, and chooses an optimal value that balances the two.

In addition to \tilde{q} , the firm also needs to set a referral wage W^R to hire a referred applicant. As discussed earlier, the referred applicant draws a random utility κ . As the firm offers a higher wage to a referred applicant, it increases the probability that she accepts the job offer. However, it also decreases the expected profits from hiring

¹²The cutoff ability level also depends on other parameters of the benefit function $\phi(\cdot)$. For brevity, I do not write them explicitly if there is no possibility of confusion.

a referral. The firm's problem, thus, is the following:

$$\begin{aligned} \max_{W^R, \tilde{q}} \Pi^R = & \left(\rho Pr(\theta_j \geq \tilde{\theta}_j^B(\sigma_L, \tilde{q})) E \left[\theta_j - [1 - F(\tilde{q} - \theta_j)] B | \theta_j \geq \tilde{\theta}_j^B(\sigma_L, \tilde{q}) \right] \right. \\ & + (1 - \rho) Pr(\theta_j \geq \tilde{\theta}_j^B(\sigma_H, \tilde{q})) E \left[\theta_j - [1 - F(\tilde{q} - \theta_j)] B | \theta_j \geq \tilde{\theta}_j^B(\sigma_H, \tilde{q}) \right] \\ & \left. - W^R \right) Pr(W^R > W^M + \kappa) \end{aligned}$$

subject to (3.6). As discussed above, (3.6) indicates that the employee adjusts his referral strategy depending on the firm's choice of \tilde{q} .

Proposition 4 *Assume $c - [1 - F(q^* - \theta_L)] B > \sigma_H > \sigma_L$. Then equilibrium behavior is as follows:*

1. *Employee i makes a referral for any applicant j with $\theta_j \geq \tilde{\theta}_j^B(\sigma_{ij}, q^*)$, where $\tilde{\theta}_j^B(\sigma_{ij}, q^*)$ is such that $\phi(\sigma_{ij}, c, \tilde{\theta}_j^B(\sigma_{ij}, q^*), q^*, B) = 0$ for $\sigma_{ij} \in \{\sigma_L, \sigma_H\}$.*
2. *The firm offers the equilibrium referral wage W^{*R} to hire a referred applicant and sets q^* that satisfies the condition $F(q^* - \theta_H) = 1 - \frac{1}{B}$.*
3. *Referred applicant j accepts the offer if $W^{*R} > W^M + \kappa_j$.*

As summarized in the above proposition, the employee's equilibrium strategy consists of setting a cutoff ability level, which depends on the strength of the social connection among other things, and referring any applicants whose abilities are above the cutoff. The firm, on the other hand, finds it optimal to hire a referred applicant rather than an anonymous applicant, it thus offers an equilibrium referral wage to a referred applicant. The referred applicant accepts the offer only if the referral wage offer is

better than her outside option, which is determined by a random utility shock as well as the market wage.

Note that the expected ability of employee i 's referral is higher than the expected ability of an anonymous applicant in equilibrium. The reason is that when the employee is offered financial incentives in the form of bonuses indexed to the referral's performance, the employee's referral decision is based on the applicant's ability as well as the strength of the social connection. In other words, bonuses help the firm align its incentives with those of the employee in referral recruitment. This result is in stark contrast to the result derived in the previous section in which the firm uses a fixed payment in an attempt to incentivize informative referrals. Therefore, a main result of the model is that the employee referrals provide a screening function only when the employee is offered financial incentives that align his incentives with those of the firm.

The empirical evidence documented by Beaman and Magruder (2011) supports this result. These authors conducted a social experiment in Kolkata, India, to understand how social networks affect job referrals. In their setting, workers are hired for a temporary job, and they are asked to refer an individual for the same job in order to earn a financial reward. The nature of financial rewards are randomized between fixed payments and a bonus contingent on the referral's performance. They find that workers refer highly skilled network members only when their reward is tied to the referral's performance. Otherwise, they are more likely to refer a relative or a close friend. Further, they find that referred applicants have higher cognitive skills

in the case of bonus treatments. Hence, their findings suggest that referrals serve a screening role only when the tension between the incentives of the employee and the firm is non-existent, or mitigated by the use of correct financial tools.

Before turning to promotions, I am going to discuss, in turn, how the expected ability of a referral is related to the social connection between the employee and the applicant, and how the firm can use the bonus scheme to alter the expected ability of a referral.

Corollary 4 *The expected ability of a referral who possesses a weak social connection with the current employee is higher. That is, $E[\theta_j | \theta_j \geq \tilde{\theta}_j^B(\sigma_L, q^*)] > E[\theta_j | \theta_j \geq \tilde{\theta}_j^B(\sigma_H, q^*)]$.*

The expected ability of a referral depends on the strength of the social connection between the employee and the applicant. Specifically, the employee refers an applicant of higher ability on average when he has a weak connection with the applicant than the case in which he has a strong connection. However, the crucial result is that the expected ability of a referral is higher than that of an anonymous applicant regardless of the strength of the social connection between the employee and the applicant. Therefore, referrals provide screening of higher-ability applicants. Yet, the higher expected ability may not translate into higher wages. The reason is that the firm incurs additional costs when it hires through referrals since it pays bonuses to employees who have made “successful” referrals. Therefore, the firm’s wage offer to referrals is reduced to take costs from paying bonuses into account. The referral wage

is higher than the market wage only if additional profits from hiring the referred applicant, who is expected to be of higher ability than an anonymous applicant, make up for the expected cost of referral bonuses.

Existing theoretical work suggests that referrals are offered higher starting salaries than anonymous applicants since the former are expected to be more productive. For example, Montgomery (1991) shows that applicants who have more ties with high-ability employees will earn higher wages. Similarly, Simon and Warner (1992) show that referred applicants' reservation wages are higher than those of nonreferrals since there is less uncertainty concerning the referrals' productivity at the firm. Therefore, the firm has to offer higher wages in order to hire through referrals. Empirical evidence concerning starting wages of new hires is consistent with this result. For example, examining data from a mid-to-large U.S. corporation, Brown, Setren, and Topa (2012) find that referrals are associated with a 2.1 percent premium on starting wages. However, empirical studies have not addressed the effect of bonuses or any other recruitment costs on the starting wages of referrals. As the current model illustrates, in addition to the referral's expected productivity, the size of referral wages is also related to the firm's recruitment costs that it would incur only if it hires through referrals. Therefore, a more appropriate test of the current model would take recruitment costs such as referral bonuses into account.

Corollary 5 *The expected ability of a referral decreases with the size of bonus B , and increases with the output threshold q^* .*

The firm can affect employee referrals by changing its bonus scheme. Specifically, when the firm offers a lower bonus or requires a higher output threshold to earn the bonus, employees refer applicants of higher ability on average. The intuition is that as the expected bonus payment increases (either due to an increase in the size of the bonus or a lower threshold), it becomes easier to outweigh the cost of referring low-ability applicants. Therefore, the employee finds it optimal to refer some applicants that he did not refer before. This lowers the expected ability of a referral. Beaman and Magruder (2011) find that when the firm offers a higher referral bonus, the referral's performance on the job decreases, which may be interpreted as lower ability, but the effect is not statistically significant in their empirical analysis.

Finally, it is instructive to discuss how adopting a social structure similar to that assumed by Montgomery (1991) alters the results of the model. Recall that Montgomery assumes that a worker is more likely to know workers of his own type. Therefore, the firm finds it optimal to solicit referrals from workers of high-ability since they are more likely to refer high-ability applicants. Note that our result that fixed payments do not provide employees with an incentive to refer higher ability applicants is valid regardless of the employees' ability levels. If we assume that employees are more likely to draw an applicant of their own type, the employee's referral decision will still be independent of the applicant's ability. However, the assumed social structure implies that referrals from high-ability employees will be more able, on average, than an anonymous applicant. Therefore, the firm will find it optimal to hire a referral if his expected productivity is high enough to make up for the cost of the fixed payment remunerated to the referrer. Hence, even when

the firm uses fixed payments it will hire referrals from high-ability employees, while low-ability employees will not refer any applicants in equilibrium.

A similar logic applies to referral bonuses. We showed that bonuses provide current employees of any ability level an incentive to refer higher-ability applicants. The assumption that employees are more likely to draw applicants of their own type slightly changes the results. The optimal strategy of the current employee will still be characterized by a cutoff ability level above which he refers any applicants. However, the firm will update its beliefs concerning the ability level of a referral according to the referrer's ability since each employee is more likely to refer an applicant of his own type. Therefore, unlike the current situation, the referral wage offer will also be a function of the referrer's ability. However, employee referrals will still serve a screening function.

3.3.3 Promotion Incentives

In this section, I incorporate promotions to the model in order to examine how their presence affects job referrals from current employees. The rationale behind promotions affecting current employees' referral decisions is that referring an applicant may alter the current employee's promotion prospects. For example, a particular employee may increase his promotion prospects by referring a lower ability applicant if he is likely to compete against his referral for a promotion. However, the effect of promotions on employee referrals is not clear-cut for two reasons. First, it is not

certain whether making a referral for a particular applicant will make the employee better off. It is obvious that the employee's probability of earning a promotion increases as the contestant's ability goes down. Less obvious is whether the employee will be better off when he refers an applicant against whom he might compete for a promotion rather than competing against a randomly drawn co-worker at the firm.

Second, when considering whether to refer lower ability applicants, the employee faces a trade-off between increasing his promotion prospects and decreasing his probability of earning a bonus. As discussed in the previous section, when bonuses are tied to the performance of referrals, they provide current employees with an incentive to refer higher ability applicants. However, the employee has also an incentive to refer a lower ability applicant in order to increase his promotion prospects. Which effect dominates depend on the relative magnitudes of incentives provided by bonuses and promotions. To elaborate on these dynamics, I first discuss how to incorporate promotions into the framework in which employees are eligible for referral bonuses. Then, I consider two cases distinguished by whether incentives for referrals provided through bonuses dominate disincentives caused by the employee's promotion prospects. As will be discussed, the case in which disincentives caused by promotion incentives dominate incentives provided through bonuses entails the situation in which employees are eligible for fixed payments rather than bonuses as a special case. Therefore, I consider the implications of having fixed payments when employees are concerned about their promotion prospects as a special case.

The firm runs promotion tournaments in the spirit of Lazear and Rosen (1981).¹³ Employees compete in pairs and the one who produced the higher level of output earns a promotion. As Lazear and Rosen show, the firm sets the promotion prize in order to elicit efficient levels of effort from its employees.¹⁴ However, I abstract away from effort choice since the goal of this paper is to examine the screening role of referrals when promotions are present rather than examining the incentive effects of promotions.

Let the wage increase associated with earning a promotion, denoted by ΔW , be exogenously determined. In other words, the firm does not take how the size of promotion prizes affects employee referrals into account when setting the size of promotion prizes. This assumption is plausible in the present context since the goal of the firm in using promotions is to assign workers to jobs to which their skills are most fitted and to provide effort incentives. The promotion prize, however, may affect the employee's referral decision if the employee faces a possibility of competition with the newly hired worker. The intuition behind this rationale is simple. The employee will be competing against a co-worker to earn the promotion prize, and his probability of earning the prize decreases with the opponent's ability. Therefore, the presence of promotions gives the employee an incentive to refer a less able applicant when there is a possibility of competition for promotions. Hence, both the firm and the employee should take the effect of promotions into account during the referral process.

¹³For extensive surveys of the tournament literature, see Gibbons and Waldman (1999), Prendergast (1999), Waldman (2010) and Lazear and Oyer (2010).

¹⁴Promotion prizes also provide incentives for employees to invest in firm-specific human capital (Prendergast, 1993; Zabojnik and Bernhardt, 2001).

To model the possibility that the employee will face his own referral as a contestant, the promotion tournament is assumed to have the following structure. With probability λ employee i competes against employee j , who has been hired through i 's referral. Otherwise, he is paired with employee k whose ability is unknown to i . The probability of i earning the promotion when the contestant is j is given by $\text{prob}(y_i > y_j) = \text{prob}(\theta_i - \theta_j > \xi) = G(\theta_i - \theta_j)$, where $\xi \equiv \epsilon_j - \epsilon_i$ and $G(\cdot)$ is the cdf of ξ . When i 's contestant is employee k , his probability of earning the promotion is given by $E_{\theta_k}[\text{prob}(y_i > y_k)] = \int_{\theta_L}^{\theta_H} G(\theta_i - \theta_k) \frac{1}{\theta_H - \theta_L} d\theta_k$. Note that in the latter case the employee takes the expectation over his contestant's ability since it is unobservable to him.¹⁵ As a result, i 's probability of earning the promotion prize is a function of his own ability, as well as the referral's ability and the probability of facing the referral as a contestant:

$$P_i(\theta_i, \theta_j, \lambda) = \lambda G(\theta_i - \theta_j) + (1 - \lambda) \int_{\theta_L}^{\theta_H} G(\theta_i - \theta_k) \frac{1}{\theta_H - \theta_L} d\theta_k. \quad (3.7)$$

Consistent with the above discussion, the employee affects his probability of earning the prize through his referral decision only if λ is non-zero. Otherwise, his referral decision is independent of the promotion tournament. Therefore, I assume that $\lambda > 0$ in the rest of the discussion. The employee's utility is then given by

$$U_i = w_i + \sigma_{ij} - c + [1 - F(\tilde{q} - \theta_j)] B + \Delta W P_i(\theta_i, \theta_j, \lambda). \quad (3.8)$$

Since the employee's current wage level w_i is independent of the referral process, we

¹⁵One may argue that the employee could observe his co-worker's ability if it is observable to the firm. However, the assumed tournament structure is robust to this argument as long as the employee does not know which co-worker he will be paired with for the tournament, and the ability distribution of the firm's workforce is the same as that of job applicants.

can define the expected returns from referring applicant j as follows

$$\begin{aligned}
\phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda) &= \sigma_{ij} - c + [1 - F(\tilde{q} - \theta_j)] B + \Delta W \lambda [G(\theta_i - \theta_j) \\
&\quad - \int_{\theta_L}^{\theta_H} G(\theta_i - \theta_k) \frac{1}{\theta_H - \theta_L} d\theta_k] \\
&= \sigma_{ij} - c + [1 - F(\tilde{q} - \theta_j)] B + \Delta W \lambda \psi(\theta_i, \theta_j), \quad (3.9)
\end{aligned}$$

where $\psi(\theta_i, \theta_j)$ measures the change in the probability that employee i will earn the promotion prize when he refers applicant j . Note that the employee will draw a contestant from the whole distribution of ability if he does not make a referral. Otherwise, he will be competing against his referral j with probability λ . In which of these cases the employee would be better off is not certain, therefore the sign of $\psi(\cdot)$ is indeterminate for a given (θ_i, θ_j) pair. That is, taking the ability of the potential referral fixed, some employees increase their chances of earning the promotion prize by making a referral, whereas some others indeed reduce their probability of promotion.

Note that the probability of employee i earning the promotion decreases with the ability of the referral, thus $\psi(\cdot)$ decreases with θ_j . This weakens the employee's incentives to refer high-ability applicants. However, even though the presence of promotions generates a conflict of interest between the firm and the employee concerning referral recruitment, referral decisions may not be distorted in equilibrium. The reason is that if the incentive effects of referral bonuses are sufficiently large, they offset the disincentives induced by promotions. In other words, the expected returns from referring an applicant becomes an increasing function of the referral's ability if referral bonuses generate sufficiently strong incentives to refer high-ability

applicants. In the remainder of this section, I examine these two cases in turn.

Case 1 *The expected returns from referring an applicant increase with the applicant's ability. That is, $\phi(\cdot)$ is an increasing function of θ_j .*

I first examine the case in which expected returns from referring an applicant increase with the applicant's ability. Note that holding abilities of the employee and the applicant constant, marginal returns from referring a higher-ability applicant increase with the size of referral bonus B and decrease with the size of promotion prize ΔW and the probability of facing the referral as a contestant λ .¹⁶ The first case then follows when the referral bonus B is sufficiently large relative to $\Delta W * \lambda$ so that the employee has an incentive to refer high-ability applicants.

The employee's optimal strategy is that he will refer the applicant as long as the expected returns are non-negative. Since the expected returns increase with the applicant's ability by assumption, there exists a cutoff ability level above which the employee refers any applicant. Let $\tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)$ denote the lowest-ability applicant that employee i refers when he is eligible to earn bonuses and is concerned about his promotion prospects. Unlike the no-promotions case, the cutoff depends on the employee's own ability as well as the social connection between the employee and the applicant, and the output threshold to earn the bonus. The reason is that the employee's promotion prospects are a function of his own ability.

To examine equilibrium behavior, let us focus on an employee whose optimal

¹⁶This follows since we have $\frac{\partial \phi(\cdot)}{\partial \theta_j} = f(\tilde{q} - \theta_j)B - \Delta W \lambda g(\theta_i - \theta_j)$.

strategy is the same for both types of social connections he might have with the applicant. That is, employee i 's optimal strategy is to select a cutoff and refer any applicants whose ability is above it. The firm's optimization problem is the same as before, except (3.6) is replaced by

$$\phi(\sigma_{ij}, c, \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i), \tilde{q}, B, \theta_i, \lambda) = 0, \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\} \quad (3.10)$$

Proposition 5 *Assume $c - [1 - F(q^* - \theta_L)]B - \Delta W \lambda \psi(\theta_i, \theta_L) > \sigma_H > \sigma_L$ for a given employee i . Then equilibrium behavior is as follows:*

1. *Employee i makes a referral for any applicant j with $\theta_j \geq \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$, where $\tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$ is such that $\phi(\sigma_{ij}, c, \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i), q^*, B, \theta_i, \lambda) = 0$ for $\sigma_{ij} \in \{\sigma_L, \sigma_H\}$.*
2. *The firm offers the equilibrium referral wage $W^{*R}(\theta_i)$ to hire a referred applicant and sets q^* that satisfies the condition $F(q^* - \theta_H) = 1 - \frac{1}{B}$.*
3. *Referred applicant j accepts the offer if $W^{*R}(\theta_i) > W^M + \kappa_j$.*

The structure of the equilibrium is the same as that in no-promotions case. However, the major difference occurs on the optimal strategy of employees who adjust their behavior to exploit the referral process in order to increase their promotion prospects. Since the cutoff above which the employee refers any applicant depends on the employee's own ability as well, the expected ability of a referral is also a function of the employee's ability. The firm determines referral wages consistent with its beliefs concerning the expected ability of a referral. Therefore, unlike in the no-promotions

case, the referral wage is a function of the referrer's ability. Note, however, that the optimal output threshold to earn the bonus q^* is the same as before. The reason is that the employee's promotion prospects are not affected by the bonus scheme. Specifically, the marginal increase in the referral's expected ability due to a small increase in \tilde{q} is not affected by the employee's promotion prospects, thus it is the same as before.

As in the no-promotions case, the expected ability of a referral is higher if the social connection between the employee and the applicant is weak. However, since the firm is not able to observe the strength of the social connection between the employee and the job applicant, it forms beliefs concerning the social connection and offers a referral wage consistent with those beliefs. This implies that the expected ability of a referral is a function of the proportion of low-biased and high-biased employee-applicant pairs. Since low-biased employees refer applicants of higher ability on average, the expected ability of a referral increases with the probability that the social connection between a given employee-applicant pair is weak.

To simplify the discussion, let the applicant whose ability is just equal to the cutoff be referred to as the marginal referral. Note that the marginal referral is the lowest-ability applicant that the employee finds it optimal to refer. Therefore, the expected ability of a referral is monotonically increasing with the ability of the marginal referral. The following result shows how the expected ability of a referral changes when promotions are incorporated.

Corollary 6 *The expected ability of a referral is higher when promotions are present*

if and only if the employee reduces his probability of promotion by referring the marginal referral. That is, for a given employee i and a given value of σ_{ij} , $\tilde{\theta}_j^B(\sigma_{ij}, q^*) < \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$ if and only if $\psi(\theta_i, \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)) < 0$.

To understand the mechanics behind this result, consider an applicant j' such that $\tilde{\theta}_j^B(\sigma_{ij}, q^*) < \theta_{j'} < \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$. When promotions are absent, the employee refers this applicant since the expected benefits exceed the cost of referring. When promotions are introduced, the employee will choose not to refer the same applicant if and only if referring the applicant reduces his probability of promotion, i.e., if $\psi(\theta_i, \theta_{j'}) < 0$. Otherwise, he will still find it optimal to refer this applicant. This result also implies that incorporating promotions reduces the expected ability of a referral if referring the marginal referral increases the employee's promotion prospects. Therefore, it shows that employees' promotion incentives may still distort their referral decisions even when referrals continue to serve a screening function.

Corollary 7 *If referring a particular applicant reduces the employee's probability of promotion, the expected ability of that referral is an increasing function of the employee's probability of competing against his own referral. That is, for a given (θ_i, θ_j) pair, $\tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$ increases with λ if and only if $\psi(\theta_i, \theta_j) < 0$.*

Recall that the parameter λ is the probability that the employee will compete against his own referral. Therefore, it measures the effect of referral decisions on promotion prospects; higher values of λ imply a greater effect of referral decisions on the employee's promotion prospects. How the value of λ affects the critical value depends

on whether the employee benefits from referring the applicant in terms of increasing his probability of promotion. If referring a given applicant reduces the employee's probability of earning a promotion (i.e., if $\psi(\theta_i, \theta_j) < 0$ for a given (θ_i, θ_j) pair), the critical value increases with the value of λ . The reason is that higher values of λ imply a greater decrease in the employee's promotion prospects when $\psi(\theta_i, \theta_j) < 0$. Since the expected benefits increase with the applicant's ability by assumption, the employee sets a higher cutoff in order to offset the decrease in the probability of promotion. Conversely, if referring a given applicant increases the employee's probability of promotion, he sets a lower cutoff as the value of λ increases.

Finally, the relationship between the referrer's ability level and the expected ability of the referral is of interest. If higher ability employees set a higher cutoff ability level to refer applicants, it means that there is a positive correlation between the referrer's ability and the expected ability of a referral. However, this result follows only if the employee's promotion prospects decrease with his ability level. Here is the formalization of the result.

Corollary 8 *The expected ability of a referral increases with the referrer's ability level if and only if the referrer's promotion prospects decrease with his own ability level. That is, $\tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$ is an increasing function of θ_i if and only if $\frac{\partial \psi(\theta_i, \theta_j)}{\partial \theta_i} < 0$.*

Consider two employees i and i' such that $\theta_i > \theta_{i'}$. When the promotion prospects decrease with the referrer's ability, we have $\psi(\theta_i, \theta_j) < \psi(\theta_{i'}, \theta_j)$ for a given applicant j . In other words, employee i' experiences a higher reduction in his expected utility

since his promotion prospects diminish more than those of employee i . In order to offset this reduction in his expected utility, employee i' sets a higher cutoff to refer applicants. Note that the last step of this reasoning follows since, by assumption, the expected returns from referring an applicant increase with the applicant's ability.

As discussed earlier, Montgomery (1991) shows that assortative matching in social networks results in a positive correlation between the expected ability of a referral and the referrer's ability. In that sense, our result shows the link between the current model and that of Montgomery. That is, without assuming assortative matching, the positive correlation is possible only if the employee's promotion prospects do not increase with his own ability. Otherwise, a negative correlation will be observed as promotions generate greater distortions at the high end of the ability distribution.

Case 2 *The expected returns from referring an applicant decrease with the applicant's ability. That is, $\phi(\cdot)$ is a decreasing function of θ_j .*

Next, I consider the case in which the expected returns from referring an applicant decrease with the applicant's ability. As the opposite of the first case, promotion incentives are stronger than those provided through bonuses so that the employee does not have an incentive to refer higher-ability applicants. In other words, either the promotion prize ΔW or the probability that the employee will compete against his own referral λ is sufficiently large. Note that the presence of promotions leads to a situation in which the employee indeed has an incentive to refer low-ability applicants in order to increase his promotion prospects. Hence, this is the worst-case

scenario from the firm's point of view as the incentives of the employee are fully misaligned with those of the firm concerning referral recruitment. Note that this case also arises when the firm does not offer bonuses, i.e. when $B = 0$. Therefore, the results discussed for this case applies to the situation in which the firm uses fixed payments to solicit referrals from employees who are concerned about their promotion prospects.

The employee continues to refer any applicants that will bring him non-zero expected returns. However, there is a major change in his optimal strategy. Since the expected returns decrease, rather than increasing, with the applicant's ability, there exists a critical value above which the employee does not refer any applicants. Let $\bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)$ denote the cutoff for given values of σ_{ij} and \tilde{q} . Since $\phi(\cdot)$ decreases with θ_j , for any $\theta_{j'} > \bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)$ we have

$$\phi(\sigma_{ij}, c, \bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i), \tilde{q}, B) > 0 > \phi(\sigma_{ij}, c, \theta_{j'}, \tilde{q}, B). \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\}$$

This means that the expected ability of a referral is lower, regardless of the strength of the social connection, than that of an anonymous applicant. Therefore, employee referrals do not serve a screening function in this case.

Proposition 6 *In equilibrium, the employee does not refer any applicants, and the firm hires an anonymous worker at the market wage.*

Note that a necessary condition to have referral hiring in equilibrium is that the expected ability of a referral is higher than the expected ability of an anonymous

applicant. If this condition is not satisfied, the firm cannot make up for the costs of referral bonuses, thus it does not hire any referred applicants. Anticipating that the firm will not hire any referred applicants, the employee then does not refer any applicants in equilibrium since it is costly to refer an applicant. Incorporating promotions into the model shows that the employee may have conflicting interest with the firm when making a referral decision. In that case, the firm does not find any referrals from the employee credible enough to hire the referred applicant. However, as the discussion of the two cases illustrates, the firm can mitigate the tension of interests using referral bonuses.

3.4 Conclusion

In this paper, I investigate two potential mechanisms that generate a conflict of interest between the firm and current employees concerning referral recruitment. First, I show that the current employee's referral decision is affected by the strength of his social connection to the applicant. Specifically, the employee has an incentive to refer applicants of lower ability, on average, if he has a strong social connection to the applicant. Second, I examine how the employee's promotion incentives affect his referral decision. The intuition of incorporating promotions is that the employee will have an incentive to refer applicants of lower ability if he faces a possibility of competition for promotions against his own referral.

The model points out the importance of providing the “correct” incentives with

the current employee to elicit successful referrals. Specifically, when the employee is eligible to earn a fixed payment for referring an applicant, his decision is independent of the applicant's ability. Thus, he has an incentive to refer applicants with whom he has strong social connections. Therefore, employee referrals do not serve a screening function. However, the firm can incentivize the employee to refer high-ability applicants by offering bonuses which are contingent on the referral's performance on the job. In that case, the firm hires referred applicants since employee referrals screen more able workers. The presence of promotions complicates the employee's referral decision. If the employee is not provided with sufficiently strong incentives through bonuses, he will have an incentive to refer applicants of lower ability. Therefore, the firm does not hire through referrals in this case. If, however, bonuses generate sufficiently strong incentives so that the employee finds it optimal to refer high-ability applicants, then referrals still serve a screening function.

As discussed before, the empirical evidence documented in the literature supports the model's predictions concerning the effect of fixed payments and bonuses on employee referrals. However, the relationship between the current employee's promotion prospects and his referrals decisions have not been investigated. In that sense, the results of the paper point out directions for further research.

APPENDIX A

APPENDIX OF CHAPTER 1

Parametric Restrictions:

Let $\theta_t^+(j, j+1)$ denote the threshold ability level in period t at which the current employer is indifferent between assigning worker i to job level j and $j+1$. The parametric restrictions regarding the current employer's promotion decisions are as follows.

(i) $E[\theta] < \theta_1^+(1, 2)$. That is, on average young workers are more productive in job level 1.

(ii) $\theta_2^e(y_H) > \theta_2^+(1, 2) > \theta_2^e(y_L)$. This condition states that middle-aged workers who produced the high (low) level of output when they were young are expected to be more productive at job level 2 (job level 1).

(iii) $\theta_3^e(y_L, y_H) > \theta_3^+(1, 2)$. This condition ensures that old workers with the output history (y_L, y_H) are expected to be more productive at job level 2.

(iv), $\theta_3^e(y_H, y_L) > \theta_3^+(1, 2)$. That is, old workers with the output history (y_H, y_L) are expected to be more productive at job level 2.

(v), $\theta_3^e(y_H, y_H) > \theta_3^+(2, 3)$. This condition tells us that old workers with the output history (y_H, y_H) are expected to be more productive at job level 3.

Proof of Proposition 1.

Let us first solve for the optimal contract in the second period. Following Rogerson (1985), one can replace the the incentive constraint (1.7) by the first-order condition of the worker's problem given by (1.11).¹ Let $\lambda_1 \geq 0$ and $\lambda_2 \geq 0$ be the Lagrange multipliers associated with participation constraint (1.8) and the constraint from the worker's problem (1.11), respectively. Then, the first-order necessary conditions are given by

$$-1 + \lambda_1 = 0 \quad (\text{A.1})$$

$$-p_j^e(y_1) + \lambda_1 p_j^e(y_1) + \lambda_2 [\theta_2^e(y_1)] = 0 \quad (\text{A.2})$$

$$\begin{aligned} & \theta_2^e(y_1)[s_2[Y_H^j - Y_L^j] + \pi_3^e(y_1, y_H) - \pi_3^e(y_1, y_L)] + \\ & + \lambda_1[\theta_2^e(y_1)[\beta_{j2} + [\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)]] - g'(e_j^*)] + \lambda_2[-g''(e_j^*)] = 0 \quad (\text{A.3}) \end{aligned}$$

(A.1) indicates that $\lambda_1 = 1$, thus the participation constraint is binding. By complementary slackness, (A.2) indicates that $\lambda_2 = 0$ since $\theta_2^e(y_1) > 0$. Imposing $\lambda_1 = 1$, $\lambda_2 = 0$ and the replaced incentive constraint into (A.3) gives (1.9). (B.2) follows from the binding participation constraint. Since the participation constraint (1.8) is binding and there is an infinitesimal moving cost borne by the worker, all middle-aged workers remain with their period-1 employers.

Proof of Proposition 2. Let us derive the optimal contract for the last period. Similar to the second-period problem, one can replace the incentive constraint (1.2) by the first-order condition of the worker's problem given by (1.6). Let $\lambda_1 \geq 0$ and

¹It can be showed that $Pr(Y_{ijt} = Y_H^j) = [e_{ijt}\theta_i]$ satisfies the two sufficient conditions, the monotone likelihood-ratio condition (MLRC) and the convexity of the distribution function condition (CDFC), to use the first-order approach. Also note that the convexity of $g(\cdot)$ provides the sufficiency condition for the worker's maximization problem.

$\lambda_2 \geq 0$ be the Lagrange multipliers associated with participation constraint (1.3) and the constraint from the worker's problem (1.6), respectively. Then, the first-order necessary conditions are given by

$$-1 + \lambda_1 = 0 \quad (\text{A.4})$$

$$-p_j^e(y_1, y_2) + \lambda_1 p_j^e(y_1, y_2) + \lambda_2 [\theta_3^e(y_1, y_2)] = 0 \quad (\text{A.5})$$

$$s_3 \theta_3^e(y_1, y_2) [Y_H^j - Y_L^j] - \theta_3^e(y_1, y_2) \beta_{j3} + \lambda_1 [\theta_3^e(y_1, y_2) \beta_{j3} - g'(e_j^*)] + \lambda_2 (-g''(e_j^*)) = 0 \quad (\text{A.6})$$

(A.4) indicates that $\lambda_1 = 1$, thus the participation constraint (1.3) is binding. By complementary slackness, (A.5) indicates that $\lambda_2 = 0$ since $\theta_3^e(y_1, y_2) > 0$. Imposing $\lambda_1 = 1$, $\lambda_2 = 0$ and the replaced incentive constraint into (A.6) gives (1.4). (B.3) follows from the binding participation constraint. Similar to the second period, since the participation constraint (1.8) is binding and there is an infinitesimal moving cost borne by the worker, all old workers remain with their period-1 employers.

Before presenting the proofs omitted in the text, let us introduce the expected net surplus function and show that it is strictly increasing and convex with respect to s and $E\theta$.

Lemma 1 *Let $E\theta \equiv E_t[\theta_i | I_{it}]$ be a shorthand for the worker i 's expected ability conditional on information available at period I_{it} , which includes her output and job assignment history until period t . Let us write the expected net surplus as a function of the expected ability of the worker, $E\theta$, and the term reflecting the firm-specific human capital, s , i.e., $X^j(E\theta, s) = sY_L^j + s[Y_H^j - Y_L^j]e_j(E\theta, s)E\theta - g(e_j(E\theta, s))$.*

Then, $X^j(E\theta, s)$ is strictly increasing in $E\theta$ and s , and is strictly convex.

Proof of Lemma. First note that the worker's utility maximization problem implies that $g'(e_j) = E\theta s[Y_H^j - Y_L^j]$. Hence, using the implicit function theorem one can write e_j as a function of $E\theta$ and s , i.e., $g'(e_j(E\theta, s)) = E\theta s[Y_H^j - Y_L^j]$. This implies that $\frac{\partial e_j(E\theta, s)}{\partial E\theta} = \frac{s[Y_H^j - Y_L^j]}{g''(e_j(E\theta, s))} > 0$ and $\frac{\partial e_j(E\theta, s)}{\partial s} = \frac{E\theta[Y_H^j - Y_L^j]}{g''(e_j(E\theta, s))} > 0$ since $g(\cdot)$ is a convex function.

Using this result, one can prove the lemma:

$$\begin{aligned} \frac{\partial X^j(E\theta, s)}{\partial E\theta} &= s[Y_H^j - Y_L^j] \left[\frac{\partial e_j(E\theta, s)}{\partial E\theta} E\theta + e_j(E\theta, s) \right] - g'(e_j(E\theta, s)) \frac{\partial e_j(E\theta, s)}{\partial E\theta} \\ &= s[Y_H^j - Y_L^j] e_j(E\theta, s) + \frac{s[Y_H^j - Y_L^j]}{g''(e_j(E\theta, s))} [s[Y_H^j - Y_L^j] E\theta - s[Y_H^j - Y_L^j] E\theta] \\ &= s[Y_H^j - Y_L^j] e_j(E\theta, s) > 0 \text{ for all } e_j(E\theta, s) > 0, \end{aligned}$$

$$\frac{\partial X^j(E\theta, s)}{\partial s} = Y_L^j + [Y_H^j - Y_L^j] e_j(E\theta, s) E\theta > 0.$$

This proves that $X^j(E\theta, s)$ is strictly increasing in $E\theta$ and s . We also need to compute the second-order partial derivatives of the expected surplus function in order to show that it is strictly convex.

$$\frac{\partial^2 X^j(E\theta, s)}{\partial E\theta^2} = s[Y_H^j - Y_L^j] \frac{\partial e_j(E\theta, s)}{\partial E\theta} = \frac{(s[Y_H^j - Y_L^j])^2}{g''(e_j(E\theta, s))} > 0,$$

$$\frac{\partial^2 X^j(E\theta, s)}{\partial s^2} = E\theta[Y_H^j - Y_L^j] \frac{\partial e_j(E\theta, s)}{\partial s} = \frac{(E\theta[Y_H^j - Y_L^j])^2}{g''(e_j(E\theta, s))} > 0.$$

This implies that the Jacobian of X^j is positive definite, which is sufficient to show that it is strictly convex.

Note that one can also write down the expected net surplus at a competing firm by replacing the term s by h . This is equivalent to imposing the restriction $s = h$. Therefore, the expected net surplus function is strictly convex with respect to h .

Proof of Corollary 1 $s_3[Y_H^3 - Y_L^3] > s_3[Y_H^2 - Y_L^2] > s_3[Y_H^1 - Y_L^1]$ since $[Y_H^3 - Y_L^3] > [Y_H^2 - Y_L^2] > [Y_H^1 - Y_L^1]$ and $s_3 > 1$. Therefore, we have $\beta_{33} > \beta_{23} > \beta_{13}$.

To show that $\beta_{22} > \beta_{12}$ let us first rewrite the bonus payments for middle-aged workers using the expected net surplus function as follows:

$$\begin{aligned}\beta_{22} &= s_2[Y_H^2 - Y_L^2] + [\pi_3^e(y_H, y_H) - \pi_3^e(y_H, y_L)] \\ &= s_2[Y_H^2 - Y_L^2] + (s_3E[Y^3|y_H, y_H] - E[Y^{o3}|y_H, y_H]) - (s_3E[Y^2|y_H, y_L] - E[Y^{o2}|y_H, y_L]) + [g(e_{33}^o) - g(e_{33}^*)] - [g(e_{23}^o) - g(e_{23}^*)] \\ &= s_2[Y_H^2 - Y_L^2] + X^3(E[\theta|H, H], s_3) - X^3(E[\theta|H, H], h) - X^2(E[\theta|H, L], s_3) + X^2(E[\theta|H, L], h)\end{aligned}$$

$$\begin{aligned}\beta_{12} &= s_2[Y_H^1 - Y_L^1] + [\pi_3^e(y_L, y_H) - \pi_3^e(y_L, y_L)] \\ &= s_2[Y_H^1 - Y_L^1] + (s_3E[Y^2|y_L, y_H] - E[Y^{o2}|y_L, y_H]) - (s_3E[Y^1|y_L, y_L] - E[Y^{o1}|y_L, y_L]) + [g(\widetilde{e}_{23}^o) - g(\widetilde{e}_{23}^*)] - [g(e_{13}^o) - g(e_{13}^*)] \\ &= s_2[Y_H^1 - Y_L^1] + X^2(E[\theta|L, H], s_3) - X^2(E[\theta|L, H], h) - X^1(E[\theta|L, L], s_3) + X^1(E[\theta|L, L], h).\end{aligned}$$

First, assume that $s_3 = h$. Then, the above condition simplifies to $s_2[Y_H^2 - Y_L^2] > s_2[Y_H^1 - Y_L^1]$, which is true since $[Y_H^2 - Y_L^2] > [Y_H^1 - Y_L^1]$ and $s_2 > 0$.

Next, assume that $s_3 > h$. We need to show that terms that include expected net surplus in the last period is increasing in the human capital parameter, s . In other words, ignoring the first terms, $s_2 [Y_H^2 - Y_L^2]$ and $s_2 [Y_H^1 - Y_L^1]$, we need to show that the following strict inequality holds:

$$X^3(E[\theta|H, H], s_3) - X^3(E[\theta|H, H], h) - X^2(E[\theta|H, L], s_3) + X^2(E[\theta|H, L], h) > X^2(E[\theta|L, H], s_3) - X^2(E[\theta|L, H], h) - X^1(E[\theta|L, L], s_3) + X^1(E[\theta|L, L], h).$$

One can rearrange this as the following:

$$X^3(E[\theta|H, H], s_3) - X^2(E[\theta|H, L], s_3) - X^2(E[\theta|L, H], s_3) + X^1(E[\theta|L, L], s_3) > X^3(E[\theta|H, H], h) - X^2(E[\theta|H, L], h) - X^2(E[\theta|L, H], h) + X^1(E[\theta|L, L], h).$$

Since $E[\theta|H, H] - E[\theta|H, L] \geq E[\theta|L, H] - E[\theta|L, L]$ and $X(\cdot)$ is strictly convex, terms at both sides are positive. Moreover, that $X(\cdot)$ is strictly convex and $s_3 > h$ implies that the term on the left hand side is greater than the term on the right hand side. Hence the result.

Proof of Corollary 2 Let us rewrite the bonus payment for the middle-aged worker using the expected net surplus: $\beta_{j2} = s_2[Y_H^j - Y_L^j] + X^{j+1}(E[\theta|y_1, H], s_3) - X^{j+1}(E[\theta|y_1, H], h) - X^j(E[\theta|y_1, L], s_3) + X^j(E[\theta|y_1, L], h)$. Note that when $s_3 = h$, the result follows since the terms related to the last period cancel out and $s_3[Y_H^j - Y_L^j] > s_2[Y_H^j - Y_L^j]$. To show the inequality for $h < s_3$ let us re-arrange the terms as follows:

$$\beta_{j3} > \beta_{j2},$$

$$s_3[Y_H^j - Y_L^j] > s_2[Y_H^j - Y_L^j] + X^{j+1}(E[\theta|y_1, H], s_3) - X^{j+1}(E[\theta|y_1, H], h) -$$

$$\begin{aligned}
& X^j(E[\theta|y_1, L], s_3) + X^j(E[\theta|y_1, L], h), \\
& s_3[Y_H^j - Y_L^j] + X^{j+1}(E[\theta|y_1, H], h) - X^j(E[\theta|y_1, L], h) > s_2[Y_H^j - Y_L^j] + \\
& X^{j+1}(E[\theta|y_1, H], s_3) - X^j(E[\theta|y_1, L], s_3).
\end{aligned}$$

Note that the second term on the left hand side, that is, $X^{j+1}(E[\theta|y_1, H], h) - X^j(E[\theta|y_1, L], h)$ is increasing in h . As we know that the inequality holds for $h = s_3$ and the term on the left hand side is increasing in h , one can conclude that there are values of h such that $h < s_3$ and that the inequality holds.

Proof of Corollary 3 Note that the term $X^{j+1}(E[\theta|y_1, H], h) - X^j(E[\theta|y_1, L], h)$ is equivalent to $\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)$. As it is increasing in h , the prize for promotion increases with h . On the contrary, β_{j2} decreases with h since the term, $\bar{U}_3(y_1, y_H) - \bar{U}_3(y_1, y_L)$, is deducted from the bonus payment. (1.11) indicates that the efficient effort level remains constant since the prize for promotion and the part for the career-concern incentive in the bonus payment cancel out. That is, the efficient level of effort does not depend on h .

APPENDIX B

APPENDIX OF CHAPTER 3

Proof of Proposition 1. When employee i earns a fixed payment of F by referring an applicant, he refers applicants of any ability as long as the cost of referring does not exceed the benefits. However, this decision is independent of the applicant's ability. Therefore, the expected ability of a referral is at most equal to the expected ability of an anonymous applicant. In that case, the firm makes zero expected profits from hiring the referred applicant since in addition to wages paid to the newly hired worker, it also has to pay F to the referrer. Hence, in equilibrium the firm hires an anonymous applicant at the market wage and makes zero expected profits. Anticipating this, the employee does not refer any applicants not to incur the referring cost c in vain.

Proof of Proposition 2. Before solving the firm's optimization problem, let us see how the choice of \tilde{q} affects the employee's referral decision. As discussed in the text, given the values of $(\sigma_{ij}, c, \tilde{q}, B)$, the employee chooses a cutoff $\tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})$ above which he refers any applicants. Therefore, the cutoff is implicitly defined by

$$\phi(\sigma_{ij}, c, \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q}), \tilde{q}, B) = 0, \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\} \quad (\text{B.1})$$

Using the implicit function theorem, one can show that

$$\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial \tilde{q}} = - \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B)}{\partial \tilde{q}} / \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B)}{\partial \theta_j} = - \frac{-f(\tilde{q} - \theta_j)B}{f(\tilde{q} - \theta_j)B} = 1,$$

for $\sigma_{ij} \in \{\sigma_L, \sigma_H\}$. Using this result, the firm chooses values of W^R and \tilde{q} that maximize its expected profits from hiring a referred applicant. Let us rewrite the

expected profits from hiring a referral Π^R more explicitly as

$$\begin{aligned} \max_{W^R, \tilde{q}} \Pi^R &= \frac{W^R - W^M + \bar{\kappa}}{2\bar{\kappa}} \left(\frac{\rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_L, \tilde{q})}^{\theta_H} [\theta_j - [1 - F(\tilde{q} - \theta_j)] B] \partial\theta_j \right. \\ &\quad \left. + \frac{1 - \rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_H, \tilde{q})}^{\theta_H} [\theta_j - [1 - F(\tilde{q} - \theta_j)] B] \partial\theta_j - W^R \right) \end{aligned}$$

subject to (B.1). First order conditions with respect to W^R and \tilde{q} , respectively, as follows

$$\begin{aligned} &\frac{W^{*R}}{2\bar{\kappa}} \left(\frac{\rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_L, q^*)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j + \frac{1 - \rho}{\theta_H - \theta_L} \right. \\ &\quad \left. \int_{\tilde{\theta}_j^B(\sigma_H, q^*)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j - W^{*R} \right) \\ &\quad - \left(\frac{W^{*R} - W^M + \bar{\kappa}}{2\bar{\kappa}} \right) = 0 \end{aligned} \tag{B.2}$$

$$\begin{aligned} &\frac{\rho}{\theta_H - \theta_L} \frac{\partial \tilde{\theta}_j^B(\sigma_L, \tilde{q})}{\partial \tilde{q}} \left(-1 + B - BF(q^* - \tilde{\theta}_j^B(\sigma_L, q^*)) \right) + \frac{\rho B}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_L, q^*)}^{\theta_H} f(q^* - \theta_j) \partial\theta_j \\ &\quad + \frac{1 - \rho}{\theta_H - \theta_L} \frac{\partial \tilde{\theta}_j^B(\sigma_H, \tilde{q})}{\partial \tilde{q}} \left(-1 + B - BF(q^* - \tilde{\theta}_j^B(\sigma_H, q^*)) \right) \\ &\quad + \frac{(1 - \rho)B}{\theta_H - \theta_H} \int_{\tilde{\theta}_j^B(\sigma_H, q^*)}^{\theta_H} f(q^* - \theta_j) \partial\theta_j = 0 \end{aligned} \tag{B.3}$$

For brevity, let us define

$$\begin{aligned} A &\equiv \frac{\rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_L, q^*)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j + \frac{1 - \rho}{\theta_H - \theta_L} \\ &\quad \int_{\tilde{\theta}_j^B(\sigma_H, q^*)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j. \end{aligned}$$

Then, (B.2) implies that

$$W^{*R} = \frac{1}{2} \left(W^M + A - \bar{\kappa} \right).$$

Imposing $\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial \tilde{q}} = 1$ into (B.3) and rearranging it gives $F(q^* - \theta_H) = 1 - \frac{1}{B}$.

Proof of Corollary 1. It suffices to show that $\tilde{\theta}_j^B(\sigma_L, q^*) > \tilde{\theta}_j^B(\sigma_H, q^*)$. Evaluating (B.1) at σ_L and σ_H gives:

$$\sigma_L - c + \left[1 - F(q^* - \tilde{\theta}_j^B(\sigma_L, q^*))\right] B = \sigma_H - c + \left[1 - F(q^* - \tilde{\theta}_j^B(\sigma_H, q^*))\right] B$$

Rearranging the term gives $F(q^* - \tilde{\theta}_j^B(\sigma_H, q^*)) > F(q^* - \tilde{\theta}_j^B(\sigma_L, q^*))$. The result follows.

Proof of Corollary 2. The expected ability of referred applicant j in equilibrium is given by

$$E[\theta_j] = \rho E[\theta_j | \theta_j \geq \tilde{\theta}_j^B(\sigma_L, q^*)] + (1 - \rho) E[\theta_j | \theta_j \geq \tilde{\theta}_j^B(\sigma_H, q^*)]. \quad (\text{B.4})$$

Since (B.4) monotonically increases with $\tilde{\theta}_j^B(\sigma_L, q^*)$, it suffices to show that $\tilde{\theta}_j^B(\sigma_L, q^*)$ increases with q^* and decreases with B . We already showed that $\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial \tilde{q}} = 1$. To show that $\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial B} > 0$, let us implicitly differentiate (B.1) with respect to B :

$$\frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B)}{\partial \theta_j} \left[\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial \tilde{q}} \frac{dq^*}{dB} + \frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial B} \right] + \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B)}{\partial B} = 0$$

Evaluating the whole expression at q^* gives

$$\frac{\partial \tilde{\theta}_j^B(\sigma_{ij}, \tilde{q})}{\partial B} = -\frac{1 - F(q^* - \theta_j)}{f(q^* - \theta_j)B} - \frac{1}{B^2} \frac{1}{f(q^* - \theta_j)} < 0.$$

Proof of Proposition 3. Since $\frac{\partial \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{\partial \tilde{q}} = 1$, the solution illustrated for Proposition 2 still applies. However, the referral wage W^{*R} changes to take the

change in the expected ability of the referral into account. For brevity, let us define

$$B \equiv \frac{\rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^B(\sigma_L, q^*, \theta_i)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j + \frac{1 - \rho}{\theta_H - \theta_L} \int_{\tilde{\theta}_j^P(\sigma_H, q^*, \theta_i)}^{\theta_H} [\theta_j - [1 - F(q^* - \theta_j)] B] \partial\theta_j.$$

Then, we have

$$W^{*R} = \frac{1}{2} \left(W^M + B - \bar{\kappa} \right).$$

Proof of Corollary 3. Evaluating (3.6) and (3.10) at q^* gives

$$\left[F(q^* - \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)) - F(q^* - \tilde{\theta}_j^B(\sigma_{ij}, q^*)) \right] B = \Delta W \lambda \psi(\theta_i, \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i))$$

Thus, $\tilde{\theta}_j^B(\sigma_{ij}) > \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)$ if and only if $\psi(\theta_i, \tilde{\theta}_j^P(\sigma_{ij}, q^*, \theta_i)) > 0$.

Proof of Corollary 4. Implicitly differentiating (3.10) gives

$$\frac{\partial \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{\partial \lambda} = - \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \lambda} / \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \theta_j}, \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\}$$

Since the term in the denominator is positive by assumption, and $\frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \lambda} = \psi(\theta_i, \theta_j)$, $\frac{\partial \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{\partial \lambda}$ is positive if and only if $\psi(\theta_i, \theta_j)$ is negative.

Proof of Corollary 5. Implicitly differentiating (3.10) with respect to θ_i gives

$$\frac{\partial \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{\partial \theta_i} = - \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \theta_i} / \frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \theta_j}, \quad \text{for } \sigma_{ij} \in \{\sigma_L, \sigma_H\}$$

Since the term in the denominator is positive by assumption, and $\frac{\partial \phi(\sigma_{ij}, c, \theta_j, \tilde{q}, B, \theta_i, \lambda)}{\partial \theta_i} = \frac{\partial \psi(\theta_i, \theta_j)}{\partial \theta_i}$, $\frac{\partial \tilde{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{\partial \theta_i}$ is positive if and only if $\frac{\partial \psi(\theta_i, \theta_j)}{\partial \theta_i}$ is negative.

Proof of Proposition 4. As the discussion in the text illustrates, the employee sets a cutoff $\bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)$ above which he does not refer any applicants. In that case, the expected ability of a referral is given by $E[\theta_j | \text{referred by } i] = \frac{\theta_L + \bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i)}{2}$ which is lower than $\hat{\theta}$ since $\bar{\theta}_j^P(\sigma_{ij}, \tilde{q}, \theta_i) < \theta_H$. The remainder of the logic is the same as the one discussed in the Proof of Proposition 1.

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