ESSAYS ON PROMOTION AND TURNOVER

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ABSTRACT

This dissertation compares three of the leading theories on wage and promotion dynamics, tournament theory, job assignment theory, and signaling theory, via their predictions on the impact of promotion on employees' turnover behavior. In the first chapter entitled "Theory on Promotion and Turnover", I incorporate turnover into all three theories through an employer-employee specific match factor and generate three predictions from each theory. The first two are similar among the theories and the third distinguishes among them. Specifically, all the theories predict that promotions are positively correlated with wage levels and that performance ratings are positively related to the probability of promotion. Regarding promotion and turnover dynamics, the tournament model predicts that promotion is negatively related to turnover, while the job assignment model predicts that neither promotion nor the wage is related to turnover. Further, under certain conditions, the signaling model predicts that promotion is positively related to turnover and that the wage is negatively related to turnover controlling for promotions. In the second chapter entitled "Theoretical Extensions on Promotion and Turnover," I further extend both tournament and job assignment theories by adding firm specific human capital. These extensions enrich the predictions of both theories regarding promotion and turnover dynamics. Specifically, the further extended tournament theory predicts that promotion is negatively correlated with turnover while the wage is negatively correlated with turnover controlling for promotions. On the other hand, the further extended job assignment theory predicts that promotion is positively correlated with turnover while the wage is negatively correlated with turnover given promotions. In the third chapter of my dissertation entitled

"Evidence on Promotion and Turnover," I test these predictions using a dataset on employees from a single firm in the financial services industry in the U.S. I first show that tournament theory better captures the promotion-turnover dynamics in the full sample. I then conduct further tests by breaking up the sample into a high level subsample and a low level subsample. I find that tournament theory better explains the promotion-turnover dynamics in higher level jobs, while both signaling theory and job assignment theory with firm specific human capital better explain the dynamics in lower level jobs. I interpret this finding as evidence consistent with both an incentive argument related to Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach discussed in Waldman (2013).

BIOGRAPHICAL SKETCH

Ying Wang was born in Beijing, China in January, 1986. She earned her B.S. degree in Economics at Tsinghua University in July, 2008. She then studied Economics at the Department of Economics at Cornell University and will earn her Ph.D. degree in Economics in August, 2013.

I dedicate my dissertation to my mother, Ling Wang, for her love and support.

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CHAPTER 1

THEORY ON PROMOTION AND TURNOVER

1. Introduction

Theory on promotion inside firms identifies three distinct roles of promotions, which are to reward previous performance, to assign workers to tasks, and to signal a worker's ability to outside firms. Three leading theories of wage and promotion dynamics, tournament theory, job assignment theory, and signaling theory, each models promotion with a focus on one of the three roles. Specifically, tournament theory sees promotion as an incentive device, job assignment theory treats promotion as a labor allocation device, whereas signaling theory sees promotion as a signal of ability. This paper aims to investigate how these three roles of promotions affect workers' turnover decisions differently by comparing the predictions of these three theories for promotion and turnover dynamics.

Because none of the theories originally incorporated turnover, I start my analysis with the introduction of turnover into all the theories by assuming there is an employer-employee specific match factor that enters workers' utility functions as a disutility of effort. Moreover, there is asymmetric learning about match qualities so that the realization of each match is only observable to the worker. Because the asymmetric learning assumption suggests that firms are unable to identify the quality of matches, workers with sufficiently poor matches do not get fully compensated and eventually change employers.

With turnover integrated in this way, each theory generates three predictions. The first two predictions are similar between the three theories. The third distinguishes among them. Specifically, all three theories predict that promotions are positively related to wages, and that output is positively related to the probability of promotion. As for the third prediction, tournament theory predicts that promotion is negatively related to turnover, job assignment theory predicts that promotion is not related to turnover, while signaling theory predicts that promotion is positively related to turnover under certain conditions.

To understand these predictions note that wage increases upon promotion in the job assignment model and signaling model are driven by wage offers from outside firms, while those in the tournament model are designed to induce efficient effort and turnover. As a result, there is rent extraction in both the job assignment and the signaling models regarding a worker's potential good matches but not in the tournament model. These differences explain the different predictions between the models.

Because the market wage is independent of a worker's job assignment in the tournament model while there is a large wage increase at promotion, there is a negative relationship between promotion and turnover according to tournament theory. In addition, because there is symmetric learning of abilities in the job assignment model while asymmetric learning of abilities in the signaling model, the amount of rent extracted is independent of job assignment in the former model while it increases with the distance between a worker's realized ability and expected ability in the latter model. Because turnover is determined by the amount of rent extracted in both the job assignment and the signaling models, the job assignment model predicts that promotion has no relationship with turnover. In addition, when the average difference between the realized and expected abilities of the promoted workers is lower than that of the non-promoted workers, the signaling model predicts that promotion is positively related to turnover.

The contribution of this chapter is that I extend the tournament, the job assignment, and the signaling theories by incorporating turnover and derive novel and testable predictions from each theory. In addition, because each theory makes a different prediction regarding promotion and turnover dynamics, I am able to test which theory best matches the data. In a later chapter, "Evidence on Promotion and Turnover", I test these predictions using data from a U.S. financial services firm.

The outline of this chapter is as follows. Section 2 offers a brief literature review. Section 3 develops the theories and testable implications. Section 4 concludes.

2. Literature Review

In this section, I review tournament, job assignment, and signaling theories as well as related empirical literature, with a special emphasis on promotion and turnover. Given the vast number of studies in related fields, I restrict my attention to the most important papers.

2.1. Literature on Tournament Theory

Tournament theory, developed by Lazear and Rosen (1981), proposed a payment scheme based on the rank order of workers' outputs. In their basic setting, a firm hires two identical workers where each worker's output depends on both effort and a stochastic term. At the beginning of the game, the firm sets a high wage for the worker who ends up with the higher output and a low wage for the worker who ends up with the lower output. The workers then choose their effort levels accordingly to maximize expected utilities. One of the key insights from Lazear and Rosen's study is that, by appropriately choosing the wage spread, firms can induce efficient effort levels even when effort itself cannot be observed.

A number of studies extend Lazear and Rosen's model to take into account more complex and realistic issues. These studies include but are not limited to Rosen's (1986) model of multi-round tournaments, Lazear's (1989) model of sabotage and wage compression, and Meyer's (1992) model of multi-stage tournaments with the possibility of biased tournament contests.[1] The aforementioned studies each generates testable predictions. For example, Lazear and Rosen's (1981) analysis predicts that promotions are associated with large wage increases. Also, it predicts that the size of wage increases associated with a promotion is positively related to the size of the pool from which the promoted worker is drawn. Moreover, Rosen (1986) predicts the existence of a convex wage structure in multi-round tournaments, where the wage increases associated with promotions are greater at higher job levels.[2]

Each of the predictions above is well supported by empirical studies. For example, Murphy (1985), Lazear (1992), Baker, Gibbs, and Holmstrom (1994a, 1994b), and McCue (1996) find that promotions are associated with large wage increases. Moreover, O'Reilly, Main, and Crystal (1988) find that the size of wage increases associated with promotions is positively related to the size of the pool from which the promoted worker is drawn. Further, Lambert, Larcker, and Weigelt (1993), Eriksson (1999), and Bognanno (2001) find evidence consistent with the convex wage structure. However, there is currently no existing tournament literature, theoretical or empirical, that focuses on turnover.[3]

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[1] Other papers building on Lazear and Rosen (1981) include but are not limited to Malcomson (1984), O'Keeffe, Viscusi, and Zeckhauser (1984), Garvey and Swan (1992), and Drago and Garvey (1998).
[2] See Rosen (1986), Prendergast (1999), and Waldman (2013) for more details on the convex wage structure prediction.
[3] See Lazear and Oyer (2012) and Waldman (2013) for more discussion of the empirical evidence on tournament theory.

2.2. Literature on Promotion and Job Assignment

The job assignment theory of Gibbons and Waldman (1999) integrates three principle elements of the literature on wage and promotion dynamics, namely, job assignment, on the job human capital acquisition, and symmetric learning. In their basic setup, workers have either high or low innate ability. Each worker lives for multiple periods and the proportion of high ability workers is public information. In each period, there are three types of jobs, the productivities of which depend on both abilities and a stochastic term. Additionally, the return to ability increases with job level. There is incomplete information regarding ability in the sense that neither firms nor the worker in question directly observe it throughout the game. Lastly, Gibbons and Waldman (1999) assume symmetric learning of ability in the sense that all participants of the game are equally informed about it at any point in time through observations of output. As a result, in each period, firms allocate workers to the jobs that maximize expected profits, while each worker chooses a wage offer to accept to maximize expected utility. In equilibrium, each worker is paid according to her expected productivity and is promoted to a higher level job if her perceived ability is above a certain cutoff point. In a closely related study, Gibbons and Waldman (2006) further enrich this job assignment theory by incorporating schooling and the acquisition of task specific human capital.[4]

Similar to tournament theory, job assignment theory also generates rich empirical predictions, including a positive relationship between promotions and wage increases, serial correlation

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[4] Related literature on job assignment includes Sattinger (1975), Rosen (1982), and Waldman (1984a); that on human capital acquisition includes Becker (1962), Kahn and Huberman (1988), and Prendergast (1993); and that on symmetric learning includes Harris and Holmstrom (1982) and Farber and Gibbons (1996). Papers that build on the study of Gibbons and Waldman (1999) include Lluis (2005) and Ghosh (2007).

between wage increases, and that workers who receive large wage increases earlier at one job level are promoted faster to the next. Further, each prediction listed above is supported by a number of empirical studies. For example, empirical studies mentioned in the tournament section find evidence consistent with the positive relationship between promotions and wage increases. Moreover, corresponding to the second prediction, Baker, Gibbs, Holmstrom (1994a, 1994b), Lillard and Weiss (1979), and Hause (1980) find that wage increases are serially correlated. Finally, in support of the third prediction, Rosenbaum (1984), Baker, Gibbs and Holmstrom (1994a, 1994b), and Podolny and Baron (1997) find that workers who receive wage increases earlier at one level of the job ladder are promoted faster to the next.[5] As is the case with the tournament literature, there is currently no existing job assignment literature, theoretical or empirical, that focuses on turnover, except for Ghosh (2007) which I discuss in more detail in the following subsection.

2.3. Literature on Asymmetric Learning and Signaling

The idea of asymmetric learning and promotion as a signal of ability was first proposed by Waldman (1984). The asymmetric learning idea, which first appeared in Waldman (1984) and Greenwald (1986), is the idea that each worker's current employer accrues more accurate information regarding the worker's ability than outside firms. Because of the existence of asymmetric learning, Waldman (1984) argues that outside firms may use promotion as a signal of each worker's ability. Two of the key conclusions of the signaling theory are, there are large wage increases upon promotion and the probability of promotion is below the efficient level.

[5] See Waldman (2012) for a more complete discussion of the predictions and relevant empirical studies.

Following the signaling idea of Waldman (1984), Bernhardt (1995) studies how the composition of a worker's skills and the non observability of a worker's ability affect wage and promotion paths. Similar to the findings of Waldman (1984), Bernhardt (1995) finds that there is inefficient promotion due to employers' exploitation of their private knowledge of an able worker's ability. In addition, Bernhardt provides explanations for fast track promotion plans and other empirical regularities. [6]

There are several empirical studies that have found consistent evidence with the signaling role of promotion. For example, Belzil and Bognanno (2010) find that past speed of promotion is negatively related to current promotion probabilities, which is consistent with the signaling perspective of past promotions. As another example, DeVaro and Waldman (2012) study how the signaling role of promotion interacts with education using the Baker, Gibbs, and Holmstrom (1994a, 1994b) dataset which is also the dataset I employ. This paper finds consistent evidence of the signaling role of promotion. Specifically, signaling is important for understanding the differences between promotion practices concerning bachelor's and master's degree holders.[7]

2.4. Match Literature on Turnover

To incorporate turnover into tournament, job assignment, and signaling theories, I follow the insights of the match literature on turnover. Match theory concerning labor market turnover can be mainly divided into two categories. Papers in the first category model a match as a "pure search good" (e.g., Burdett, 1978; Mortensen, 1978). That is, a match dissolves because of the arrival of new information on alternative potential matches. Papers in the second category, in

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[6] See also Zabojnik and Bernhardt (2001) and Ghosh and Waldman (2010) for related analyses.

[7] See also Okamuar (2011) and Bognanno and Melero (2012) for other recent papers that have found empirical evidence consistent with the signaling role of promotions.

contrast, treat a match as an “experience good”. That is, the only way to determine the quality of a match is to form and “experience” it. Despite the differences in the details of the matching procedure, each type of model captures several well documented empirical findings, such as the negative relationship between turnover and seniority.[8]

A classic model that falls into the second category is Jovanovic (1979). In this study, Jovanovic assumes that matches follow a non-degenerate distribution and enters into workers’ productivity functions. There is imperfect information and symmetric learning on match qualities on both sides of the market in the sense that workers’ outputs are instantaneously observed by both workers and firms. In equilibrium, wages are determined by the expected marginal productivities conditional on all the information available at that time and a worker switches employers if her revealed productivity at the current firm is relatively low. The two stylized facts Jovanovic (1979) captures are the positive relationship between wage and tenure and the negative relationship between separation probability and tenure.

Novos (1995), Ghosh (2007), and Peterson (2011) adopt an alternative approach of modeling match as an “experience good”. Different from Jovanovic (1979), Novos and the others enter match into a worker’s utility function as a disutility of effort. For example, Novos builds a model with match introduced as disutility of effort to study the interactions between labor market imperfections and the scope of the firm. He finds that firms offer wider ranges of jobs than the first best outcome when facing adverse selection and uncertain preferences from the labor market. Meanwhile, Peterson (2011) uses this match structure to study employee bonding and turnover efficiency.

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[8] A partial list of the empirical studies that support both types of models include Parsons (1977), Mincer and Jovanovic (1982), and Topel and Ward (1992).

Of these papers the one closest to mine is Ghosh (2007), which develops a theory incorporating turnover into a job assignment framework. Ghosh’s theory explains several well documented empirical findings, such as the negative relationship between tenure and turnover and the serial correlation in wage increases. It is worth noting that, even though both Ghosh’s (2007) model and my job assignment model incorporate match as disutility of effort, the empirical phenomena we attempt to explain are quite different. For example, when it comes to turnover, Ghosh’s model aims to capture the negative relationship between turnover and seniority, while mine seeks to investigate the impact of promotion on turnover.[9]

3. Models and Testable Implications

This section enriches the tournament model, the job assignment model, and the signaling model with labor turnover and derives three testable implications from each of them.

3.1. Extension of the Tournament Model

My tournament model extends the classic one-period model of Lazear and Rosen (1981). For the purpose of studying how promotion affects a worker’s subsequent turnover behavior, in my extension I consider a two-period model along the lines of Waldman (2003). Additionally, for tractability reasons, I introduce turnover into the model following Novos’ approach instead of

[9] It is worth noting that Ghosh’s (2007) model could be used to derive the prediction that promotion has no impact on turnover. However, this prediction was not explicitly derived or discussed in his paper.

Jovanovic's. That is, the model generates turnover through an employer-employee specific match factor that enters workers' utility functions as disutility of effort.[10]

3.1.1. The Model

There is a pool of ex-ante homogeneous workers, where each worker lives for two periods and the number of workers is denoted by n_w. There are multiple firms in the market, where the number of firms is denoted by n_f. Moreover, the numbers of workers and firms satisfy the relationship $n_f > 2n_w$. Assume each firm runs one tournament in the first period, where each tournament consists of two workers.[11] In addition, each firm can choose to hire more workers in the second period. Further, assume there is a single job in each period, the production of which depends both on workers' effort levels and a stochastic term. Specifically, worker i in period t produces $y_i^t = b + e_i^t + \varepsilon_i^t$, where $e_i^t \in [0, +\infty)$ denotes worker i's effort choice in period t and ε_i^t denotes a stochastic term that is distributed independently across time and individuals with

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[10] I adopt Novos' approach instead of Jovanovic's because it is more tractable in terms of the extension of the job assignment model. To understand why, recall that Jovanovic enters matches into workers' production functions and allows symmetric learning of the matches among all participants of the game via observing workers' outputs. However, in the job assignment model, there is also symmetric learning of abilities through observing output. Because both of these learning procedures take place through observing employee output, Jovanovic's way of modeling turnover complicates the job assignment model by making it hard to disentangle these two learning procedures. To keep the extensions of the tournament and the job assignment models as similar and tractable as possible, I adopt Novos' approach for all of the models' extensions. Moreover, my conjecture is that the choice between these two approaches should have no impact on each model's predictions.

[11] For simplicity, assume that a firm has to hire either two workers or no worker at all in the first period. Thus, the employment dynamics in period 1 is the following. Each firm makes a wage offer. Workers then apply. If no worker or only one worker applies, the firm retracts the offer and makes a new offer. If more than two workers apply, because of the homogeneity assumption, the firm randomly chooses two workers from the applicants. This matching procedure continues until all workers are employed. Because of the assumption that $n_f > 2n_w$, there is no unemployment in equilibrium. On the other hand, there are $n_f - 2n_w$ number of firms with zero employment in equilibrium. As a final note, one can generalize this assumption to allow each firm to run multiple tournaments. However, such a generalization would have little impact on the predictions of the model.

mean zero and variance σ_ε^2.[12] Moreover, let $F(y,e)$ and $f(y,e)$ denote the cumulative distribution function and density function of ε_i^t, and assume that F satisfies the monotone likelihood ratio property (MLRP) and the convexity of distribution function condition (CDFC).[13] Assume further that effort e_i^t is associated with disutility of effort $C(e_i^t)$, where $C' \geq 0, C" > 0$, $C'(0) = 0$, and $C(0) = 0$.

For each worker i, there is a match factor α_i following a uniform distribution on the interval $[-a, a]$, where $a > 0$. Moreover, let $u(\alpha) \equiv \frac{1}{2a}$ denote the density function of the uniform distribution. Assume that a is large enough so that there is strictly positive turnover in equilibrium. Further, assume the match factor is both firm and worker specific in the sense that a worker who switches employers is assigned a new match factor that is independent of the previous draw. Also, each match factor enters the worker's utility function as disutility of effort, i.e., worker i's total disutility of effort is given by $\tilde{C}(e_i^t) = \alpha_i + C(e_i^t)$. Moreover, assume there is asymmetric learning of match qualities in the sense that the realization of a match is only observable to the worker. As a result of this asymmetric learning assumption, firms are unable to distinguish good matches from bad matches. Therefore, workers with sufficiently bad matches do not get fully compensated for the matches and leave eventually. Finally, I assume both workers and firms are risk neutral, the price of output is normalized to 1, and there is a zero discount rate.

[12] The term b is a strictly positive constant. This assumption ensures that wages in equilibrium are strictly positive.

[13] Note that the MLRP and CDFC properties guarantee the validity of the first order approach in solving the maximization problem. To ensure MLRP holds, I assume $\frac{d}{dy}\left(\frac{f_e(y,e)}{f(y,e)}\right) \geq 0$, where $f_e(y,e) = \frac{d}{de} f(y,e)$. Likewise, to ensure CDFC holds, I assume $F(y, \lambda e + (1-\lambda)e') \leq \lambda F(y,e) + (1-\lambda)F(y,e')$, where $\lambda \in [0,1]$. See Rogerson (1985) for a more detailed discussion of the first order approach.

Now consider the timing of the game. There are two periods in the game where each period contains five stages. In period 1.1, each firm announces the first period wage W_Y and the second period wages W_P and W_{NP}, where W_P and W_{NP} are promised to the winner and the loser of the tournament, respectively. In period 1.2, each worker chooses a firm to apply to, while each firm hires either two or none of the applicants.[14] In period 1.3, each worker chooses a first period effort to maximize her expected lifetime utility. In period 1.4, nature assigns a match factor α_i to each worker i which is the worker's match quality with the current firm. Finally, at the end of period 1, each worker privately learns her match quality, while each firm observes workers' outputs, makes the promotion decision, and pays the first period wage W_Y.

[14] See footnote 11 for details.

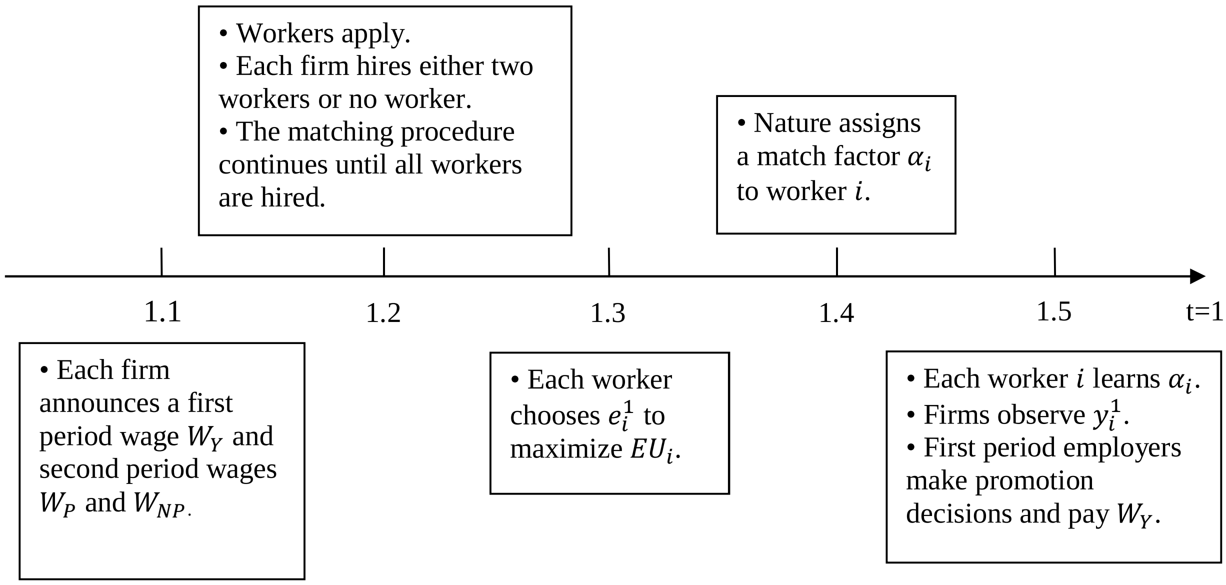

Figure 1.Timing of the Tournament Model, Period 1

In period 2.1, current firms offer second period wages, while outside firms simultaneously make market wage offers. In period 2.2, firms make wage offers. Each worker, on the other hand, chooses a wage to accept and makes her turnover decision based on the match she observes and the wages she is offered. In period 2.3, each worker chooses a second period effort level to maximize her expected utility in period 2. In period 2.4, nature assigns a new match factor to each worker who switched employers, which is independent of the previous draw. Lastly, at the end of period 2, workers who switched employers receive the market wage W_m, those who stayed and ended up with the higher output earn the high wage W_P, and those who stayed and ended up with the lower output earn the low wage W_{NP}.[15]

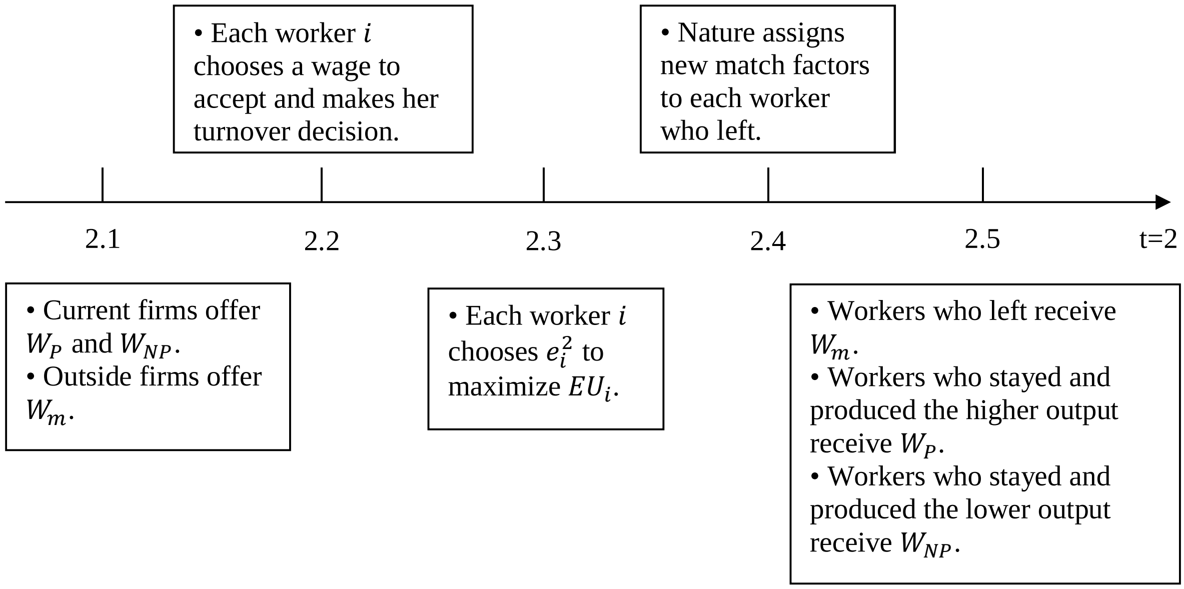

Figure 2. Timing of the Tournament Model, Period 2

3.1.2. Analysis

In this subsection I focus on the symmetric perfect Bayesian Nash equilibrium of this game. Note that a perfect Bayesian Nash equilibrium is a refinement of Nash equilibrium, where each player's strategy specifies optimal actions given the player's beliefs and the other players' actions, and beliefs are consistent with Bayes Rule. By symmetric here I mean I restrict the focus to equilibria in which each worker in a tournament chooses the same effort level.

Let us first consider the second period problem. Because period 2 is the last period of production, each worker is free of future career concerns and thus chooses the lowest effort level

[15] For tractability reasons, I assume no worker gets the high wage if the high output worker leaves. This assumption seems reasonable since the role of the high wage is to induce first period effort for the firm's first period employees. See Waldman (2003) for a related discussion.

possible, which, in this model, equals zero. Due to the fact that outside firms are only willing to pay a worker her expected second period productivity, the equilibrium market wage in period 2 must equal b.

We now consider the first period problem. In period 1, each worker chooses an effort level to maximize her expected utility given the wage offers and her rival's choice of effort. That is, given the other worker's effort level, a worker's effort choice follows the best response which is a function of wages. Because of competition at the initial stage of hiring, on the other hand, firms choose wages to maximize workers' expected utilities subject to a zero profit constraint, and the constraint from each worker's best response function.[16] We can first write down each worker i's expected utility function. Let EU_i and e_i^1 denote worker i's expected lifetime utility and first period effort choice. EU_i is given by the following expression.

$$EU_i = W_Y + P\left(y_i^1 > y_j^1\right)\{P(\alpha_i < W_P - W_m)W_P + [1 - P(\alpha_i < W_P - W_m)]W_m\} + \left[1 - P\left(y_i^1 > y_j^1\right)\right]\{P(\alpha_i < W_{NP} - W_m)W_{NP} + [1 - P(\alpha_i < W_{NP} - W_m)]W_m\} - E[\alpha_i + C(e_i^1)] - \{P\left(y_i^1 > y_j^1\right)\int_{-a}^{W_P - W_m} xu(x)dx + \left[1 - P\left(y_i^1 > y_j^1\right)\right]\int_{-a}^{W_{NP} - W_m} xu(x)dx\}$$

This expression says that worker i's expected lifetime utility equals the summation of the expected wages from the two periods net of the associated expected costs of effort. Note that the expected second period wages depend both on workers' promotion probabilities and their probabilities of staying conditional on the wage they earn, where the probability of staying is determined by a comparison of the wages of staying and leaving with the associated disutilities

[16] Papers that use a similar approach include but are not limited to Stiglitz (1975), Rothschild and Stiglitz (1976), and Ghosh and Waldman (2010).

of staying and leaving. As a result, promoted workers are less likely to change employers if the wage they earn is higher than that of non-promoted workers.

I now analyze the cost part of the utility function. Recall that the total cost of effort in each period equals the summation of a worker's match quality and the disutility of effort. Therefore, in period 1, because the expected match quality of young workers equals zero, the expected total cost equals the disutility of first period effort. In period 2, because workers exert zero effort in equilibrium, the total cost equals the expectation of match qualities. Therefore, the expected total cost for the workers who switched employers equals zero, while that for the workers who stayed is calculated by taking the expectation of match qualities over the range of values where workers stay conditional on the wages.

After the analysis of workers' expected utilities, we now switch to a firm's profit function. Define $F_l^i \equiv P(\alpha_i < W_l - W_m)$ as each worker i's probability of staying conditional on the wages W_P and W_{NP}. A firm's expected profit from a tournament can be expressed as the following.

$$E\Pi = E(y_i^1) + \{P(\mathrm{y_i^1} > \mathrm{y_j^1})F_P^i + [1 - P(\mathrm{y_i^1} > \mathrm{y_j^1})]F_{NP}^j\}E(y_i^2) + E(y_j^1) + \{P(\mathrm{y_j^1} > \mathrm{y_i^1})F_P^j + [1 - P(\mathrm{y_j^1} > \mathrm{y_i^1})]F_{NP}^j\}E(y_j^2) - \{P(\mathrm{y_i^1} > \mathrm{y_j^1})F_P^i + P(\mathrm{y_j^1} > \mathrm{y_i^1})F_P^j\}W_P - \{[1 - P(\mathrm{y_i^1} > \mathrm{y_j^1})]F_{NP}^i + [1 - P(\mathrm{y_j^1} > \mathrm{y_i^1})]F_{NP}^j\}W_{NP} - W_Y - W_Y$$

The expression above captures that each firm's expected profit equals the summation of the two workers' expected productivities over the two periods minus the expected wages. It is worth noting that a firm's second period profit depends on both the probability of promotion and the probability of workers staying, because it only receives the output and incurs the wage if a worker stays.[17]

Based on the utility function and the profit function, we can set up the maximization problem that describes the equilibrium tournament.

$\max EU_i$

$\{W_Y, W_P, W_{NP}, e_i^1\}$

$\text{s.t.} \quad E\Pi = 0$

$e_i^1 \in \operatorname{argmax} EU_i$, given W_Y, W_P, W_{NP}, and e_j^1

$\{e_i^1 \geq 0\}$

One can also view the firms' problem from an efficiency standpoint. To see how, let us first characterize the efficient effort level and turnover rates for the promoted and non-promoted workers, denoted by e_1^S, P_P^S and P_{NP}^S, respectively. We know that an effort level is efficient if it equates the marginal cost of effort to its marginal revenue. Because of the assumption that the output price is normalized to 1, e_1^S must satisfy $C'(e_1^S) = 1$ for efficiency. As for the efficient turnover rate, recall that turnover is efficient if a worker leaves whenever her current match is worse than the expected match with another potential employer. Given that the expectation of the new value for the match factor α when a worker leaves is zero, for efficiency, P_P^S and P_{NP}^S must satisfy the conditions $P_P^S = P_{NP}^S = P^S = P(\alpha > 0) = \frac{1}{2}$.[18]

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[17] Note that the profit function does not explicitly show the potential profits from external hiring in period 2. The reason is that, when hiring from the outside, firms pay each worker the exact amount of her expected output and hence make zero expected profits from such hires.

[18] One can introduce an employer switching cost to adjust the equilibrium turnover rate to be closer to that in reality.

Now I describe the firms' problem in terms of efficiency. First note that the first period wage W_Y serves to meet firms' zero profit conditions, whereas the second period wages W_P and W_{NP} simultaneously serve two roles. First, they determine the equilibrium turnover rates for promoted and non-promoted workers, respectively. Second, as is also true in Lazear and Rosen (1981), the wage spread between the two acts as an incentive to elicit positive first period effort. Consequently, the double duty of the second period wages creates a tension between the turnover rates and the effort level in equilibrium. That is, the larger the wage spread, the higher the level of effort it induces, yet the more likely the firm retains ill matched workers from the promoted pool and loses well matched workers from the non-promoted pool. Therefore, from an efficiency standpoint, in equilibrium, firms choose wages that minimize the summation of these three types of inefficiencies, namely, the insufficient first period effort, the inefficiently low turnover of promoted workers, and the inefficiently high turnover of non-promoted workers.

Below let e_1^* and e_2^* denote the equilibrium first period and second period efforts, while P_P^* and P_{NP}^* denote the equilibrium turnover rates for promoted and non-promoted workers. Moreover, let W_P^* and W_{NP}^* denote the equilibrium wage offers to the workers who are and are not promoted, W_m^* denote the equilibrium market wage, and W_Y^* denote the equilibrium first period wage offered to the young workers. The previous analysis is summarized in Proposition 1.1.

Proposition 1.1:

i) In period 1, the equilibrium effort level e_1^* is below the efficient level, i.e., $e_1^* < e_1^S$, and the equilibrium first period wage is below the expected productivity of the young workers, i.e., $W_Y^* < b + e_1^*$.

ii) In period 2, the equilibrium effort level e_2^* satisfies $e_2^* = 0$ and the market wage W_m^* satisfies $W_m^* = b$. The equilibrium wages offered to promoted and non-promoted workers satisfy $W_P^* > b > W_{NP}^*$. Moreover, $|W_P^* - b| = |W_{NP}^* - b|$.

iii) The equilibrium turnover rates of promoted and non-promoted workers satisfy $P_P^* < P^S < P_{NP}^*$.

Proposition 1.1 explicitly lays out the result of the firm's problem of inefficiency minimization. Specifically, the double duty of the second period wages results in insufficient first period effort, inadequate turnover of promoted workers, and excessive turnover of non-promoted workers in equilibrium. In addition, Proposition 1.1 says that each worker's first period wage is below her expected productivity in that period. The intuition here is that firms offer higher promotion wages to the promoted workers, and the promoted workers are more likely to stay. As a result, each firm makes strictly negative expected second period profit from each worker. Therefore, to satisfy the zero profit condition, firms offer the young workers a wage that is strictly below their expected productivity in the first period.[19]

3.1.3. Testable Implications

I develop three testable implications from Proposition 1.1.

<u>Corollary 1.1</u>: $W_P^* > W_{NP}^*$. Promotions are positively related to wage levels (Test 1).

Corollary 1.1 follows directly from Proposition 1.1, part ii). It is worth noting that this positive relationship holds even after controlling for output levels. That is to say, among the workers with the same output, those that are promoted earn higher wages. To understand why,

[19] See Appendix 1 for a complete proof of Proposition 1.1.

consider the case in which there are two tournaments, where the promoted worker in the first tournament and the non-promoted worker in the second tournament produce the same level of output. From part ii) of Proposition 1.1, we know that the first worker earns the high wage W_P^*, while the second worker earns the low wage W_{NP}^* despite the fact that they produce the same output. As a result, given output fixed, tournament theory predicts that wages are higher with promotions than without.

Along the lines of the previous argument, conditional on whether a worker is promoted, output is not correlated with wages. The reason is that, in the model, workers with the same job assignment always earn the same wage regardless of output. Using performance ratings as a proxy for output levels in the dataset I use for the empirical analysis in the third chapter of my dissertation, the argument above translates into the following testable implication. Promotions are positively related to wages with or without controlling for performance ratings, while performance ratings are not related to wages controlling for promotions.

Corollary 1.2: Across the economy, workers with higher output levels are more likely to be promoted (Test 2).

Although I describe it as a prediction, Corollary 1.2 is in a sense more like an inherent assumption of the tournament model. Because promotions in tournaments are purely based on the rank order of workers' outputs, all else equal, the higher the output, the more likely a worker gets promoted. With performance ratings as a proxy for output levels, Corollary 1.2 translates into the testable implication that performance ratings are positively related to the probability of promotion.[20]

Corollary 1.3: $P_P^* < P_{NP}^*$. Promoted workers have strictly lower turnover rates than non-promoted workers (Test 3).

Following Proposition 1.1, part iii), Corollary 1.3 says that promotion is negatively related to turnover. The intuition behind this result is that the benefit from staying for promoted workers is higher than that for non-promoted workers because the former earn higher wages by staying and the market wage is independent of whether the worker is promoted or not. On the other hand, both types of workers have the same expected cost of staying. This is because their match qualities are drawn from the same distribution. Consequently, non-promoted workers are more likely to leave due to the fact that their costs of staying are more likely to outweigh the associated benefits.[21]

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[20] Performance ratings might be related to various factors such as schooling or experience, and in that sense may not be an unbiased measure of output. However, DeVaro and Waldman (2012) argue that performance ratings in the dataset I use in the empirical study largely reflect absolute performance.

[21] Besides Corollaries 1.1-1.3, one can also derive from the tournament model that a worker with a worse match quality is weakly more likely to quit. The reason is that in the tournament model, turnover rates are characterized by a step function. Specifically, when match qualities fall in the interval $[-a, W_{NP}^* - W_m^*]$, workers never quit regardless of the job assignment. On the other hand, when match qualities fall in the interval $(W_{NP}^* - W_m^*, W_P^* - W_m^*]$, workers quit if they lose in a tournament, which happens with a probability of $\frac{1}{2}$. Finally, when match qualities fall in the interval $(W_P^* - W_m^*, a]$, workers always quit. As a result, a worker's quitting behavior follows a step function. That is, as match qualities get worse, probabilities of switching employers only weakly increase. However, we cannot test this implication because of the fact that match qualities are unobservable in the dataset.

3.2. Extension of the Job Assignment Model

This subsection extends the symmetric learning model of Gibbons and Waldman (1999) by incorporating turnover. Similar to my approach with tournament theory, I introduce turnover into the job assignment model following Novos' approach. To ensure different roles of promotions are the main driving force of any differences in the predictions of the three theories, I keep my assumptions on the match factor exactly the same as those in the tournament model.

3.2.1. The Model

There are two types of workers and each worker lives for two periods, where each firm hires n, $n > 0$, workers. A worker's innate ability, denoted by θ_i, is either high or low, $\theta_i \in \{\theta_L, \theta_H\}$, and the proportion of high ability workers, denoted by $\rho \in (0,1)$, is common knowledge. On the firm's side, there are two types of jobs in each period, denoted jobs 1 and 2. The productivity of worker i at job j in period t is given by $y_{ijt} = d_j + c_j(\theta_i + \varepsilon_{ijt})$, where ε_{ijt} denotes a stochastic term that follows a normal distribution with mean zero and variance δ_ε^2, i.e., $\varepsilon_{ijt} \sim N(0, \delta_\varepsilon^2)$. Assume that $d_1 > d_2 > 0$ and $c_2 > c_1 > 0$, i.e., job 2 is more sensitive to ability.

Moreover, assume there is incomplete information concerning ability on both sides of the market, in the sense that neither firms nor the worker in question directly observes ability through the entire game. Further, I assume symmetric learning of abilities. That is, at any point in time, all participants in the game are equally informed about each worker's ability through observing outputs. Furthermore, assumptions on the match factor remain exactly the same as in the tournament model. Specifically, for each worker, there is a match factor α_i, which follows a uniform distribution on the interval $[-a, a]$, where $a > 0$.[22] The match factor is both firm and worker specific, in the sense that a worker who switches employers is assigned a new match that is independent of the previous draw. Further, I assume asymmetric learning of the match factor, in the sense that the realization of a match is only observable to the worker. As discussed in the tournament section, because firms are unable to tell good matches from bad ones, a worker with a sufficiently bad match is not fully compensated for it and leaves.

In addition, I assume there is an employer switching cost, denoted by s, which is constant across firms and workers. In order for there to be strictly positive equilibrium turnover, I restrict s to be in the interval $(0, a)$. As a result, it is efficient for a worker to leave when the disutility from her match with the current firm is higher than the employer switching cost.[23] Finally, I assume both workers and firms are ex-ante homogeneous and risk neutral, and there is free entry into the market as well as a zero discount rate.

The timing of the game is the following. At the beginning of each period, firms simultaneously make wage offers based on workers' expected productivities. Each worker then chooses the wage offer that maximized her expected utility and makes her turnover decision based on the match quality. At the beginning of period 2 when there are multiple firms tied at the highest expected utility, I assume the worker randomly picks a wage offer to accept unless one of these came from the worker's previous employer, in which case the worker chooses to stay with that firm.

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[22] Note that I keep the uniform distribution assumption on the match factor for calculation convenience. One can easily generalize it to any continuous distribution with zero mean, as long as the distribution is the same across the individuals and is independent of workers' abilities. Such a generalization would have no effect on the predictions of the model.

[23] The role of the employer switching cost is to adjust the equilibrium turnover rate to better match the turnover rate in the real world.

Specifically, at the beginning of period 1, each firm makes a wage offer W_Y to the young workers, while each worker picks the highest wage offer to accept. During period 1, nature assigns a match factor to each worker, which is drawn from the uniform distribution defined previously. At the end of period 1, all firms (and the worker in question) simultaneously observe each worker's first period output and update their beliefs concerning the worker's ability. Meanwhile, workers observe the realizations of the matches and get paid the first period wage. At the beginning of the second period, each worker i's current employer offers her a job and a second period wage, denoted by W_i, while outside firms offer her a market wage, denoted by W_i^m, based on their updated beliefs on the worker's expected ability, denoted by θ_i^e.[24] Each worker then makes her turnover decision based on the comparison of the cost and benefit from

[24] Note that each outside firm can also offer a job at the time they make the market wage offer. However, job offers made by outside firms are not important to the dynamics of the model.

staying. If a worker leaves, nature assigns a new match factor to her, which comes from the same distribution and is independent of the previous draw. Finally, at the end of period 2, firms pay second period wages.

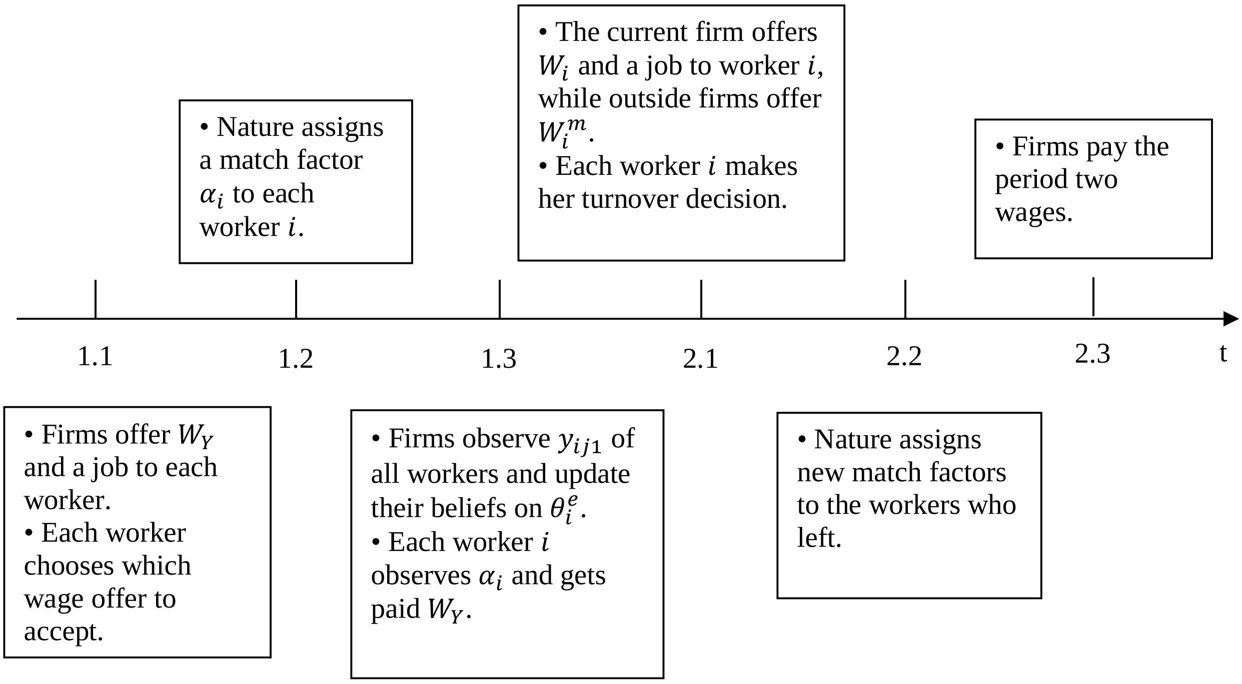

Figure 3. Timing of the Job Assignment Model

3.2.2. Analysis

This subsection analyzes the model with a focus on the perfect Bayes Nash equilibrium of this game. I begin the analysis by explaining how a firm updates its beliefs on abilities. At the beginning of the game, all firms form a common belief about a worker's expected ability, denoted by $\bar{\theta}$. Based on the distribution of θ_i, we know $\bar{\theta} = \rho\theta_H + (1-\rho)\theta_L$. At the end of period 1 when the first period outputs are observed, firms update their beliefs according to Bayes rule. Following the notation of Gibbons and Waldman (1999), let z_{i1} denote the signal the market extracts concerning worker i's ability in period 1 from observing her output in that period, i.e., $z_{i1} \equiv \frac{y_{ij1}-d_j}{c_j} = \theta_i + \varepsilon_{ij1}$. Because z_{i1} is independent of job assignment, the learning of a worker's ability does not vary across jobs.[25] Accordingly, the posterior probability of worker i being a high ability worker can be expressed as $P(\theta_i = \theta_H | z_{i1}) = \frac{P(z_{i1}|\theta_i=\theta_H)\rho}{P(z_{i1}|\theta_i=\theta_H)\rho + P(z_{i1}|\theta_i=\theta_L)(1-\rho)}$, where the conditional distributions of the signal $P(z_{i1}|\theta_i = \theta_l), l \in \{H, L\}$, are driven by the Normal distribution of the stochastic term ε_{ij1}. Finally, as defined, $\theta_i^e \equiv E(\theta_i | z_{i1})$.

As a preliminary step of the analysis, let $\tilde{\theta}$ denote the critical ability level such that it is efficient to promote a worker to job 2 if her ability is above $\tilde{\theta}$. That is, $\tilde{\theta}$ satisfies the condition $d_1 + c_1\tilde{\theta} = d_2 + c_2\tilde{\theta}$. To focus on more interesting cases, assume $\theta_L < \tilde{\theta} < \theta_H$. Also, recall that in each period, firms choose wages to maximize the expected profit from each worker based on the signal z_{i1}.

Now I analyze the profit maximization problem. Consider first the second period problem outside firms face. Because of market competition, outside firms offer a wage equal to the worker's expected second period output. Therefore, we know in equilibrium W_i^m satisfies $W_i^m = E(y_{ij2} | z_{i1})$.

We now look at the second period problem the current firm faces. Let us start by considering the benchmark case, where there is complete information regarding match qualities. That is, both firms and workers simultaneously observe the realizations of match qualities at the end of period 1. In this case, for any given market wage W_i^m, each worker i's current employer pays her a

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[25] This point is less important in my two-period model than in Gibbons and Waldman (1999) due to the fact that in my model all workers are assigned to the low level job in period 1 and there are only two periods.

wage lower than the market wage by the exact amount of the disutility of the match. That is, there is full rent extraction by firms. As a result of the rent extraction, workers switch employers when their matches with the current firms are worse than a potential match with an outside firm.

I now analyze the problem each firm faces when there is asymmetric learning regarding the match qualities.[26] Note first that the employer of each worker i makes a positive expected profit from her by offering her a wage that is strictly below her expected output. One can think of this positive profit as the rent the firm extracts from its employees' potential good matches. In other words, because a worker with a sufficiently good match has a strictly positive probability of staying even if she receives a wage that is below the market level, the current firm is strictly better off by offering the worker a wage that is below her expected output in the second period. As a result, firms earn positive expected second period profits from their employees through this rent extraction behavior.

We now solve for the second period wage W_i explicitly. Let us first write down the current firm's expected profit function regarding each worker i, denoted by $E\Pi_i$. Because each worker makes her turnover decision based on a comparison of the wage difference between leaving and staying to the associated change in expected match qualities plus the employer switching cost, we have $E\Pi_i = P(\alpha_i \leq W_i - W_i^m + s)[E(y_{ij2}|z_{i1}) - W_i]$. Based on our previous analysis, each firm's problem is to choose a wage W_i to maximize the expected profit $E\Pi_i$ given the market wage W_i^m. Define the gap between the turnover and non-turnover wages for each worker i as $\Delta_i \equiv W_i^m - W_i$. Because of rent extraction, it must be the case that $\Delta_i > 0$ in equilibrium. Moreover, due to the assumption that α_i follows a uniform distribution on the interval $[-a, a]$,

[26] Recall that asymmetric learning of the match quality refers to the assumption that only the worker in question observes the realized match quality but not the firms.

and the fact that $W_i^m = E(y_{ij2}|z_{i1})$, the expected profit can be further expressed in terms of the wage gap Δ_i, i.e., $E\Pi_i = \frac{-\Delta_i+a+s}{2a}\Delta_i$. From this expression we can see that expected profits do not vary with workers' expected abilities, which in turn means that the equilibrium wage gap is independent of job assignment. Indeed, the first order condition with respect to Δ_i is $\Delta^*= \frac{a+s}{2}$.[27] This finding further indicates that the rent extraction should not distort firms' promotion decisions.

Because of the previous analysis and the fact that production functions are linear in expected ability, it is optimal for a firm to promote a worker if her expected ability in the second period is above the efficient level $\tilde{\theta}$. As a result, we can explicitly express second period wages in terms of expected ability. Consider first market wages. According to the fact that market wages equal workers' expected productivities, workers whose expected abilities are greater than $\tilde{\theta}$ are offered $W_i^m = d_2 + c_2\theta_i^e$, while those whose abilities are below $\tilde{\theta}$ are offered $W_i^m = d_1 + c_1\theta_i^e$. Based on the market wages and the equilibrium wage gap, the equilibrium wage offered to each worker i at the current firm satisfies $W_i = W_i^m - \frac{a+s}{2}$. Also, the current firm offers to keep the worker in job 1 when expected ability is below $\tilde{\theta}$ and promote the worker to job 2 when expected ability exceeds $\tilde{\theta}$. As a concluding remark concerning the second period analysis, the equilibrium turnover rate for each worker i satisfies $P\left(\alpha_i \geq -\frac{a+s}{2} + s\right) = \frac{3a-s}{4a}$.

We now consider the first period problem. Because of market competition, each firm's expected profit is subject to a zero profit constraint. Due to the fact that firms make strictly positive profits in the second period, the zero profit constraint yields that firms must make

[27] See Peterson (2011) for a related analysis.

negative first period profits by paying young workers a wage that is higher than their expected productivity. Moreover, the wedge between the first period wage and productivity equals exactly the amount of expected second period profit. Because all the young workers are assigned to job 1 in the first period, this analysis yields that the equilibrium first period wage satisfies $W_Y^* = d_1 + c_1\bar{\theta} + \frac{(a+s)^2}{8a}$.

The analysis above is summarized in Proposition 1.2.

Proposition 1.2:

i) In period 1, all young workers are assigned to job 1 and paid a first period wage $W_Y^* = d_1 + c_1\bar{\theta} + \frac{(a+s)^2}{8a}$.

ii) In period 2, a worker with an expected ability $\theta_i^e > \tilde{\theta}$ is promoted to job 2, receives a wage of $W_i = d_2 + c_2\theta_i^e - \frac{a+s}{2}$ if she stays, and a market wage of $W_i^m = d_2 + c_2\theta_i^e$ if she switches employers; whereas one with an expected ability $\theta_i^e \leq \tilde{\theta}$ remains at job 1, receives a wage of $W_i = d_1 + c_1\theta_i^e - \frac{a+s}{2}$ if she stays, and a market wage of $W_i^m = d_1 + c_1\theta_i^e$ if she switches employers.[28]

iii) The equilibrium turnover rate of each worker i equals $P\left(\alpha_i \geq -\frac{a+s}{2} + s\right) = \frac{3a-s}{4a}$.

Proposition 1.2 demonstrates three things. First, part ii) says that promoted workers earn higher wages than non-promoted workers. This is because outside firms offer higher second period wages to promoted workers. There are two factors that determine the level of outside

[28] To keep the exposition clear, I assume a firm does not promote a worker when the firm is indifferent between promoting and not promoting the worker.

wage offers in period 2. One determinant is workers' expected abilities in period 2. Because promoted workers have higher expected abilities in the second period, wages associated with abilities are also higher for these workers. Another determinant is job assignment. Because workers who are promoted have higher expected abilities than the cutoff point $\tilde{\theta}$, these workers are more productive in the high level job than in the low level job. Because both factors indicate higher wages for the promoted workers than for the non-promoted workers, promotions are associated with higher wages.

The other point Proposition 1.2 makes is that equilibrium turnover is constant across workers. What is more important with respect to the empirical analysis is that turnover is independent of both job assignment and output. As we shall see in the following subsection, this finding is key to the derivation of the testable implication on the promotion turnover relationship in the job assignment model. Finally, because the equilibrium market wage is strictly higher than the inside wage for each worker, the equilibrium turnover rate is strictly higher than the efficient turnover rate, denoted by P^S, where $P^S = P(\alpha_i > s) = \frac{a-s}{2a}$. On the other hand, because $\tilde{\theta}$ defines the efficient level of promotion, promotion is efficient in the job assignment model.

3.2.3. Testable Implications

Below let $\overline{W}_l$ and P_l^* denote the average wage level and equilibrium turnover rate of a worker with job assignment l, where $l \in \{P, NP\}$. Next, define $\tilde{y} \equiv d_1 + c_1\tilde{\theta} = d_2 + c_2\tilde{\theta}$ as the output level such that a worker with an expected output above $\tilde{y}$ is promoted to the high level job in the second period. Proposition 1.2 yields the following three testable implications.

<u>Corollary 2.1</u>: $\overline{W}_P > \overline{W}_{NP}$. Promotions are positively related to wage levels (Test 1).

Corollary 2.1 comes from Proposition 1.2, part ii). As I have demonstrated above, promoted workers earn strictly higher wages than non-promoted workers, because the former group not only has higher levels of expected abilities, but also produces higher output due to a more efficient labor allocation. As a result, the average wage level of promoted workers is greater than that of non-promoted workers.

Note that the job assignment model makes no prediction regarding the relationship between promotions and wages if we control for output. This is because, for any given output level, all workers are either promoted or not. However, the conclusion above changes when the performance measure is coarse. When performance ratings do not reflect output levels precisely, both promotion and performance ratings can be positively related to wages. To see the logic behind this, consider a case where there are two workers, 1 and 2, who have the same performance rating but different output levels. Specifically, suppose worker 1 produces a higher output than worker 2, and that her output is higher than $\tilde{y}$ so that she is promoted to the high level job in period 2, while worker 2 stays with the low level job. From the analysis of Proposition 1.2, we know worker 1 earns a higher wage than worker 2. However, because the two workers have the same performance rating, it appears in the data that it is the promotion that drives the wage but not the performance rating. Therefore, when the performance measure is coarse, the job assignment model predicts that both promotion and performance ratings are positively related to wages.

Finally, controlling for promotions, performance ratings are positively related to wages. Because in the job assignment model, wages are determined by expected output, given job assignments, the better the performance ratings, the higher the corresponding levels of expected output, and hence the higher the wages.

Corollary 2.2: The probability of promotion weakly increases with output (Test 2).

Corollary 2.2 follows directly from the role of promotion in the job assignment model. That is, a worker is promoted if her perceived expected ability is strictly greater than the efficient level $\tilde{\theta}$. Because both production functions are linear in ability, this is equivalent to promoting a worker when her first period output is above $\tilde{y}$, and not otherwise. In other words, promotion follows a step function in the job assignment model. That is, the probability of promotion weakly increases with output.

Corollary 2.3: $P_P^* = P_{NP}^*$. Equilibrium turnover is independent of job assignment with or without wage controls (Test 3).

Corollary 2.3 says that promotion is not related to turnover. From the analysis of Proposition 1.2, part iii), we know that turnover rates are the same across workers, and thus are independent of job assignment. Similarly, neither wages nor wage increases affect turnover in the job assignment model. The reason is that firms extract the same amount of rent from each worker regardless of their outputs, and hence workers have the same incentive to leave despite the wages they earn. As a result, there is no relationship between wage and turnover.

3.3. Extension of the Signaling Model

This subsection extends the signaling model of Waldman (1984) by incorporating turnover. Similar to my approach with tournament theory and job assignment theory, I introduce turnover into the signaling model following Novos' approach. To ensure different roles of promotions are the main driving force of any differences in the predictions of all three theories, I keep my assumptions on the match factor exactly the same as those in the tournament and job assignment models.

3.3.1. The Model

In this economy there are two time periods and a single product, the price of which is normalized to 1. Each worker lives for two periods and the labor supply is fixed at 1 unit per period. In addition, I refer to the workers in the first period as the young workers and those in the second period as the old workers.

There are n_f homogeneous firms and n_w homogeneous workers in the market, where $n_f > n_w > 0$. Each firm hires 1 worker in each period. Assume each worker i's ability θ_i follows a uniform distribution on the interval $[\theta_L, \theta_H]$ and the distribution is public information. Assume there is incomplete information regarding ability in the sense that none of the participants of the game observes ability at the beginning of the game. In addition, there is asymmetric learning of ability across firms so that ability is observable to a worker's current employer at the end of the first period but remains unknown to outside firms throughout the game.

There are two jobs in each period, namely, a low level job and a high level job, where the productivity of job j for each worker i is given by $y_{ij} = d_j + c_j\theta_i$. Without loss of generality, assume $d_1 > d_2$ and $c_1 < c_2$. That is, the return to ability is higher at the high level job. Let $\bar{\theta}$ denote the expected ability of a young worker. Given ability follows a uniform distribution, we have $\bar{\theta} \equiv \frac{\theta_L + \theta_H}{2}$. To limit the number of cases to be considered here, assume $d_1 + c_1\bar{\theta} > d_2 +$

$c_2\bar{\theta}$, i.e., it is efficient to allocate young workers to the low level job.[29] Moreover, assume workers accumulate firm specific human capital k, where $k > 0$. As a result, productivity for an old worker i at job j equals $y_{ij} = (1 + k)(d_j + c_j\theta_i)$.

I now discuss the assumptions on the match factor. For each worker i there is a match factor α_i which satisfies the following four assumptions. First, $\alpha_i \sim U[-a, a]$ and is independently distributed across workers.[30] Second, match is firm and worker specific in the sense that a worker who switches employers is assigned a new match factor which is independent of the previous draw. Third, match enters a worker's utility function. Fourth, there is asymmetric learning of the match quality between the worker and the firms in the sense that only the worker observes the match quality but not the firms. Finally, assume both firms and workers are risk-neutral, firms can only sign spot contracts, and there is free entry into the market and a zero discount rate.

The timing of the model is the following. In period 1.1, each firm makes a first period wage offer W_Y to the workers. In period 1.2, each worker chooses a wage offer to accept where her choice maximizes her expected lifetime utility. In period 1.3, nature assigns a match factor α_i and an ability level θ_i to each worker i. In period 1.4, each worker i and the current employer of this worker learn about the worker's realized ability θ_i. In addition, each worker i learns about her match quality at the current firm α_i.

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[29] Refer to footnote 93 in Appendix 2 for a related parameter restriction.

[30] Here I assume a is large enough so that the probability of turnover for each worker is in the interval (0,1). A sufficient condition to ensure this is $a > \frac{\theta_H - \theta_L}{3c_1}$.

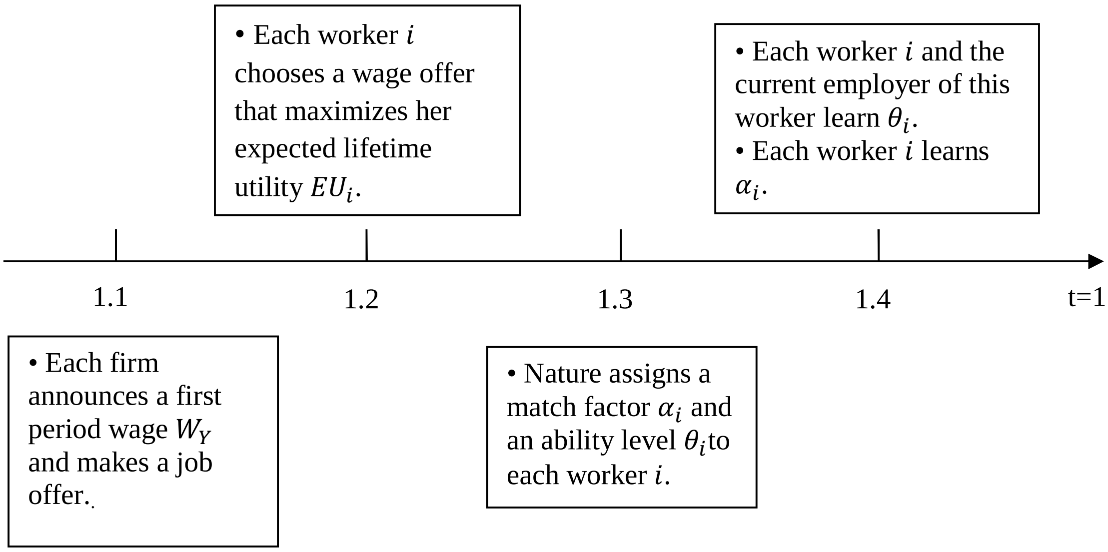

Figure 4. Timing of the Signaling Model, Period 1

In period 2.1, each firm makes job assignment decisions. Outside firms then observe these decisions and make a market wage offer W_m^j to each worker i based on the worker's job assignment j. In period 2.2, the current employer of each worker i makes a counteroffer W_i. In

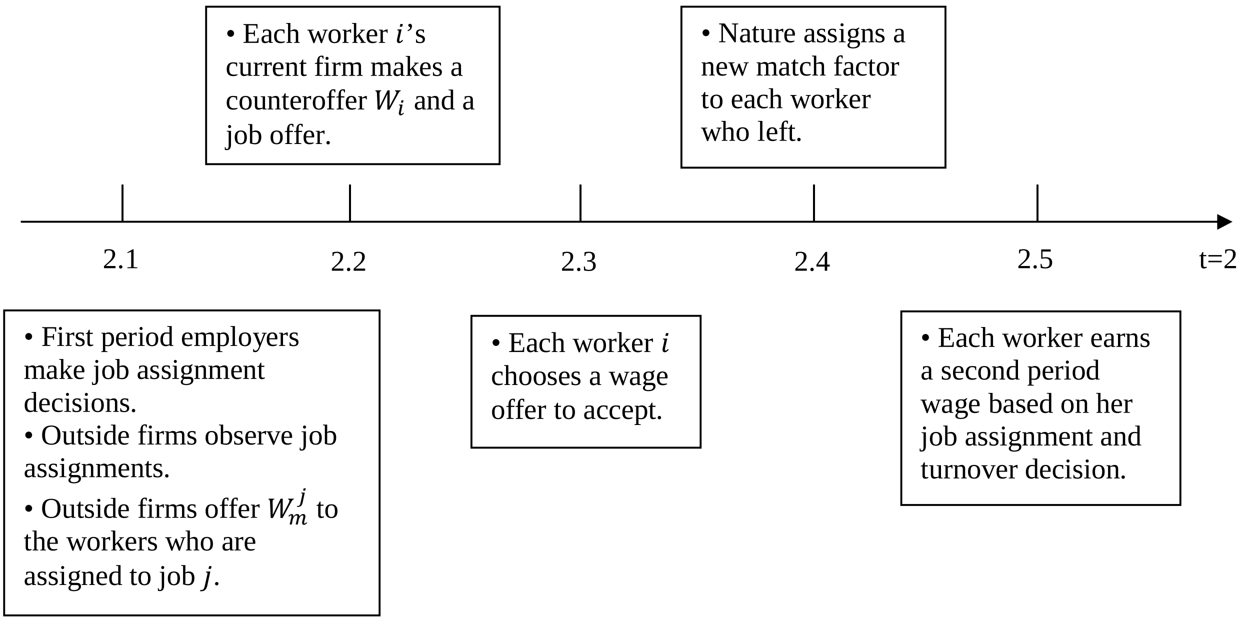

Figure 5. Timing of the Signaling Model, Period 2

period 2.3, each worker i chooses a wage offer to accept and makes her turnover decision at the same time. In period 2.4, nature assigns a new match factor α_i to each worker i who switched firms. In period 2.5, each worker earns the second period wage based on the job assignment and her turnover decision.[31]

3.3.2. Analysis

Below let W_Y^* denote the equilibrium wage in the first period while θ_e^j denotes the expected ability level of the group of workers who are assigned to job j and switch employers in the second period. Moreover, let θ' denote the ability level so that a worker with ability θ' is as productive at the low level job as she is at the high level job. That is, θ' satisfies the condition $d_1 + c_1\theta' = d_2 + c_2\theta'$. The analysis of the signaling model can be summarized as Proposition 1.3.

Proposition 1.3:

i) In period 1, all the young workers are assigned to job 1 and earn a wage W_Y^* that is higher than the expected first period productivity, i.e., $W_Y^* > d_1 + c_1\bar{\theta}$.

ii) In period 2, there exists an ability level $\theta^+ > \theta'$ such that each worker i whose ability θ_i satisfies $\theta_i > \theta^+$ is promoted to job 2 and earns a wage of $W_i^2 = \frac{1}{2}[(1+k)(d_2 + c_2\theta_i) + (d_2 + c_2\theta_e^2) - a]$ if she stays and a market wage of $W_m^2 = d_2 + c_2\theta_e^2$ if she switches employers. On the other hand, each worker i whose ability θ_i satisfies $\theta_i \leq \theta^+$ remains at job 1 (see

[31] Note that the model is different from the original model of Waldman (1984) in two ways. First, counteroffers are allowed in the wage determination process. Second, the productivity of the low level job varies with ability. Also, this model is different from Golan (2005) because of the second assumption just mentioned. Note that these two changes are important for the derivation of the promotion and turnover results of my signaling model. See Waldman and Zax (2013) for a related discussion and analysis.

footnote 28), earns a wage of $W_i^1 = \frac{1}{2}[(1+k)(d_1 + c_1\theta_i) + (d_1 + c_1\theta_e^1) - a]$ if she stays and a market wage of $W_m^1 = d_1 + c_1\theta_e^1$ if she switches employers.

iii) For each worker i, the second period wage W_i^j increases in the ability distance x_i^j, where $x_i^j \equiv \theta_i - \theta_e^j, j \in \{1,2\}$.

iv) For each worker i, the turnover rate P_i^j is a decreasing function of the return to ability c_j and the ability distance x_i^j defined in part iii), where $j \in \{1,2\}$.

Proposition 1.3 says a few things. First, the first period wage is above the expected productivity of the young workers. Because each firm makes strictly positive expected second period profit from its employees, in order to satisfy the zero profit condition, the first period wage is higher than a young worker's expected productivity, i.e., $W_Y^* > d_1 + c_1\bar{\theta}$. Second, the second period wage increases in both the realized ability of a worker and the expected ability of the group of workers with the same job assignment. Third, the difference between the turnover and the non-turnover wages in the second period is an increasing function of the ability distance $x_i^j, j \in \{1,2\}$, i.e., the distance between each worker's realized ability and expected ability. Suppose the returns to ability at the two jobs approach each other in the limit.[32] Because turnover is a decreasing function of both the ability distance x_i^j and the return to ability c_j, two workers who are assigned to different jobs will have the same turnover rate as long as their ability distances are the same.[33,34]

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[32] See footnote 37 for a discussion.

[33] See Appendix 2 for a complete proof of Proposition 1.3.

3.3.3. Testable Implications

Below let $\bar{W}^j$ and AP^j denote the average wage rate and turnover rate of the workers who are assigned to job j in period 2, respectively, where $j \in \{1,2\}$. Also, let y^+ denote the output level of a young worker whose ability equals θ^+, i.e., $y^+ = d_1 + c_1\theta^+$.

Corollary 3.1: $\bar{W}^2 > \bar{W}^1$. Workers who are promoted on average earn a higher wage than workers who are not promoted (Test 1). [35]

Corollary 3.1 follows directly from Proposition 1.3, part ii). Because the second period wage is an increasing function of realized ability and expected ability while both are higher for the promoted workers, workers who are promoted earn higher second period wages. So the average wage rate of promoted workers is higher than that of non-promoted workers.

In addition, the signaling model predicts that wage increases with performance ratings controlling for promotions. The intuition here is that the wage in the signaling model increases with both ability and the expected ability of the group of workers with the same job assignment. As a result, controlling for the job assignment, wage increases with realized ability. Since output also increases with realized ability, the signaling model says that wage increases with performance ratings given promotions.[36]

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[34] Note that the current model yields that, for workers who switch employers, it is optimal for their new employers to allocate these workers consistently with their period-one employers. See Appendix 2 for the proof of this statement.

[35] Note that instead of wage levels, Test 1 can also be expressed in terms of wage increases. That is, all three theories predict that there are large wage increases upon promotion. The reason is that the first period wages in all the theories do not vary across workers.

[36] Note that the current theory predicts that controlling for performance ratings, there is no relationship between promotion and wages. However, when performance ratings are coarse, promotion is positively related to wages. See Corollary 2.1 for a related discussion.

Corollary 3.2: The probability of promotion weakly increases with output (Test 2).

Corollary 3.2 also follows from Proposition 1.3, part ii). Because a worker is promoted if her realized ability is greater than the cutoff ability level θ^+ and because both production functions are linear in ability, the promotion rule is equivalent to promoting a worker if her first period output is above y^+, and not otherwise. In other words, promotion follows a step function of output in the signaling model. As a result, the probability of promotion weakly increases with output.

Corollary 3.3: For a sufficiently small value of firm specific human capital, k, and sufficiently similar returns to ability, c_1 and c_2, the following condition holds: $AP^2 > AP^1$.[37] Workers who are promoted are more likely to switch employers than those who are not promoted (Test 3).

Corollary 3.3 follows directly from Proposition 1.3, part iv). To begin, note first that a worker's turnover rate is determined by the distance between her realized ability and the market expected ability as well as the return to ability at that job. Therefore, the average turnover rate of any group of workers is determined by the return to ability of their job assignment as well as the average ability distance of these workers. In addition, the average ability distance is higher for non-promoted workers if firm specific human capital is sufficiently small. To understand this point, recall that the cutoff ability level for promotion θ^+ decreases with the firm specific human capital k. In particular, when k is close to 0, the cutoff ability level for promotion is closer to θ_H. In other words, there are more workers who are not promoted than those who are promoted.

[37] Specifically, holding d_1, c_1, and all the other parameters fixed and only varying d_2 and $c_2 = \tau c_1$ so that θ' remains the same, there exists an interval $(1, \epsilon)$ so that $\forall \tau \in (1, \epsilon)$, the condition $AP^2 > AP^1$ holds. See Appendix 2 for a complete proof of this statement.

Because ability follows a uniform distribution, the previous condition tells us that the average ability distance of the non-promoted workers is higher than that of the promoted workers. Since the average turnover rate decreases in both the average ability distance and the return to ability and given the assumption that the returns to ability are similar between the two jobs, workers who are promoted have a higher average turnover rate than those who are not promoted.[38]

In addition to the previous point, the signaling model also predicts that, controlling for promotion, wage is negatively related to the probability of turnover. The reason is that, given the job assignment, the equilibrium wage W_i^j increases in the ability distance x_i^j while the turnover rate P_i^j decreases in this ability distance. Therefore, given promotions, wage is negatively related to the probability of turnover.

Comparing all three tests from each theory, we can see that the three theories mainly differ in their predictions regarding the relationship between promotion and turnover. Therefore, much of the focus in the empirical analysis will be on promotion and turnover dynamics.

4. Conclusions

Current theory assigns three different roles to promotions, namely, rewarding previous performance, allocating workers to tasks, and acting as a signal of ability to outside firms. In this chapter, I compare these three roles of promotions via their implications for promotion and turnover dynamics. I use the tournament theory of Lazear and Rosen (1981) to model promotion as an incentive device, the job assignment theory of Gibbons and Waldman (1999, 2006) to

[38] Note that the current theory makes no prediction regarding the relationship between promotion and turnover controlling for wages. The reason is that given the wage, a worker is either promoted or not. That is, there exists no variation in the promotion outcomes among workers with the same wage.

model promotion as a labor allocation device, and the signaling theory of Waldman (1984) to model promotion as a signaling device. These models are all workhorse models in the personnel economics literature and each can match many empirical regularities.

By theoretically extending these three theories with turnover using a firm worker specific match factor, I show that tournament theory predicts that promotion is negatively related to turnover, job assignment theory predicts that promotion is not related to turnover, while signaling theory predicts that promotion can be positively related to turnover when certain conditions are met. The intuition behind these predictions is threefold. First, wages in both the job assignment model and the signaling model are driven by market wage offers, while those in the tournament model are designed to elicit efficient effort and turnover. As a result, in the tournament model, the difference between the turnover and non-turnover wages is higher for the promoted workers and hence the turnover rate is lower for such workers. Therefore, promotion is negatively related to turnover according to tournament theory. Second, in the job assignment model, because the difference between current firm and outside firms' wage offers is independent of the job assignment, promotion is not related to turnover according to job assignment theory. Third, due to the fact that fewer workers are promoted when firm specific human capital is small in the signaling model, the average ability distance, i.e., the distance between the realized ability and the expected ability of workers, is smaller for the promoted workers than the non-promoted workers when firm specific human capital is small. In turn, since turnover in the signaling model is negatively related to both a worker's ability distance and return to ability at the worker's job level, promotion is positively related to turnover according to signaling theory when firm specific human capital is small and returns to ability are similar across jobs.

CHAPTER 2

THEORETICAL EXTENSIONS ON PROMOTION AND TURNOVER

1. Introduction

This chapter further extends both the tournament model and the job assignment model from the previous chapter by incorporating firm specific human capital. The purpose of these extensions is to allow each model to generate within job wage dispersion, which sheds light on the wage-turnover relationship given promotions.[39]

The basic assumptions regarding human capital are several. First, only a proportion of the workers accumulate human capital. Second, workers with human capital have higher productivities than those without it. Third, human capital is firm specific in the sense that it only contributes to the productivity of a worker if she stays with her current employer. Because the human capital is firm specific, outside firms are not willing to offer a worker a higher wage if she accumulated human capital, yet the current firm of each worker has the incentive of offering different wages based on the worker's human capital outcome in order to alter her probability of leaving the firm. As a result, human capital generates wage dispersion within each job and workers with the same job assignment may have different turnover rates conditional on their human capital outcomes.

Based on the extensions with firm specific human capital, both the tournament and the job assignment models make a new prediction that wage is negatively associated with turnover controlling for promotions. The idea here is that each worker makes her turnover decision based

[39] Note that the signaling model needs no such extension due to the fact that it already incorporates firm specific human capital and predicts a negative relationship between wage and turnover controlling for promotions. See Chapter 1 for details.

on the comparison of the wage difference between the current firm's wage offer and the outside wage offer and the current match quality. Therefore, given that workers with different human capital outcomes earn different wages at their current employer but the same market wage, the workers with the higher wages thus have lower probabilities of turnover.

The outline of this chapter is as follows. Section 2 presents the extension of the tournament model and then discusses testable implications. Section 3 presents the extension of the job assignment model and then discusses testable implications. Section 4 concludes.

2. Extension of the Tournament Model with Firm Specific Human Capital

This section further extends the tournament model in the first chapter of my dissertation by incorporating firm specific human capital. In the next section, I incorporate firm specific human capital into the job assignment model following the same approach as in the tournament model.

2.1. The Model

The assumptions remain the same as in the original model except for the introduction of a productivity enhancing firm specific human capital term. As a brief review, there is a pool of ex-ante homogeneous workers where each worker lives for two periods. Also, there is a pool of homogeneous firms in the market. Each firm runs one tournament in the first period and each tournament consists of two workers. In addition, the firm can make wage offers during the second period. There is a single job in each period, the productivity of which depends on the worker's effort level, her human capital outcome, and a stochastic term.

I now describe the assumptions regarding human capital. During the first period of production in each firm, there is a probability δ of both workers in the firm's tournament accumulating firm specific human capital of an amount k, where $1 > \delta > 0$ and that $a > k > 0$.[40, 41] Further, the human capital enters the production functions of period 2 additively. That is, the second period productivity of a worker who attains the human capital is given by $y_i^2 = b + k + e_i^2 + \varepsilon_i^2$.[42] Also, there is complete information regarding the human capital accumulation across firms in the sense that each worker's human capital outcome is public information.

Assumptions on the match factor remain the same as in the original model. Specifically, for each worker i, there is a match factor α_i that follows a uniform distribution on the interval $[-a, a]$, where $a > 0$. Further, the match factor is both firm and worker specific and each match factor enters the worker’s utility function as disutility of effort. Moreover, there is asymmetric learning of match qualities so that the realization of a match is only observable to the worker. In addition, the realization of the match factor is independent of the human capital accumulation outcome. Finally, both workers and firms are risk-neutral, the price of output is normalized to 1, and there is a zero discount rate.[43]

I modify the timing of the game in the following way to incorporate the human capital accumulation. Below let W_l^r denote the second period wage offer to a worker with the promotion outcome l and human capital outcome r, where $l \in \{P, NP\}$ and $r \in \{k, 0\}$, and let W_m denote the market wage offer.

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[40] The upper bound on k ensures that matching is sufficiently important that there is strictly positive equilibrium turnover even when the human capital is accumulated. The purpose of this assumption is to reduce the number of cases to be considered here. Note that, however, this assumption is not required for any of the predictions derived from the model.

[41] For tractability reasons, I assume the two workers in a tournament either both accumulate the human capital or not. This assumption reduces the number of cases to be considered and brings no qualitative change to the predictions of the model.

[42] Alternatively, the human capital k can also contribute to the production in period 1. However, such a setup would not bring any qualitative change to the predictions of the model.

[43] Refer to Chapter 1 of the dissertation for details of these assumptions.

At the beginning of period 1, each firm announces a first period wage W_Y and second period wages (W_P^k, W_{NP}^k) and (W_P^0, W_{NP}^0) to the workers. In period 1.2, each worker chooses a firm to apply to, while each firm either hires two workers or no worker. In period 1.3, each worker chooses a first period effort to maximize the workers' expected life time utility. In period 1.4, nature assigns a match factor α_i to each worker i. Also, nature randomly assigns a realization of the human capital of the amount either k or 0 to the two workers in the tournament, where the probability the workers in a tournament both receive the human capital is δ. Finally, in period 1.5, each worker privately observes her match quality with the current firm while each firm observes workers' outputs and human capital outcomes. Each firm then makes the promotion decision and pays the first period wage W_Y.

The timing of period 2 stays roughly the same as the original setting. The major change here

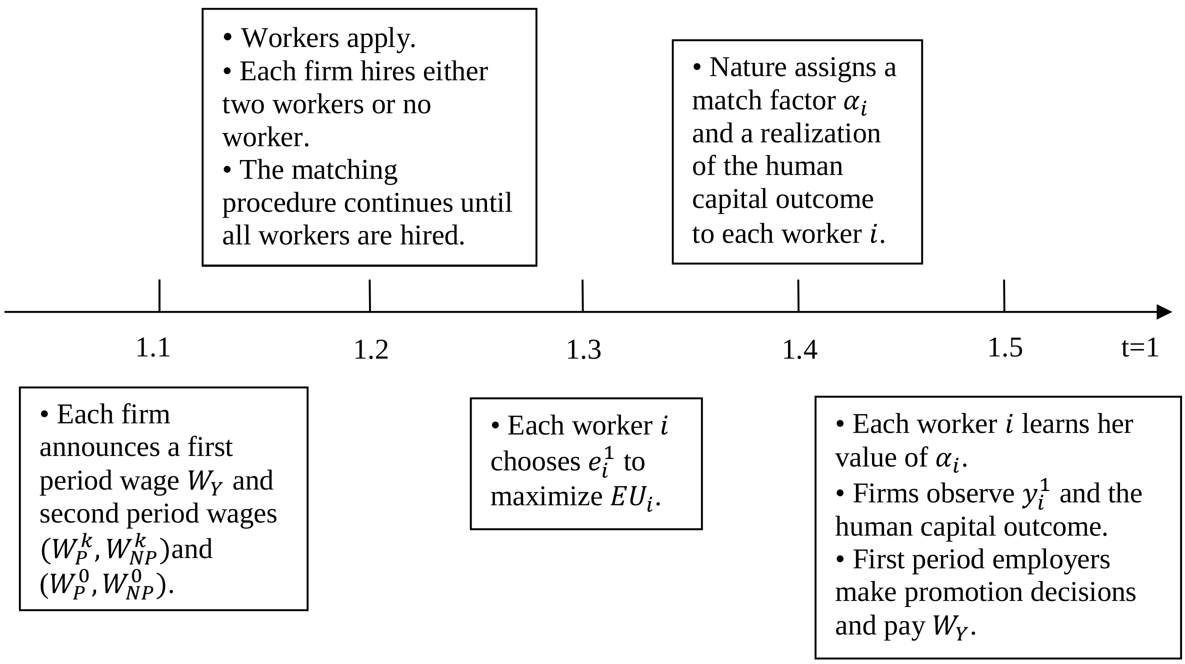

Figure 6. Timing of the Extended Tournament Model, Period 1

is the second period wage offers now depend on a worker's human capital outcome. Specifically, in period 2.1, each firm makes the second period wage offer W_l^r, where $l \in \{P, NP\}$ and $r \in \{k, 0\}$, while outside firms make the market wage offer W_m. In period 2.2, each worker chooses a wage to accept and makes her turnover decision based on the match quality and the wages. In period 2.3, nature assigns a new match factor to each worker who switched employers, which is independent of the previous draw. In period 2.4, each worker chooses a second period effort to maximize her expected utility in period 2. Lastly, in period 2.5, workers who switched employers receive the market wage W_m, those who stayed and ended up with the higher outputs earn the high wage W_P^r, while those who stayed and ended up with the lower outputs earn the low wage W_{NP}^r, where $r \in \{k, 0\}$.[44]

[44] As in the original setting, I assume no worker gets the high wage if the high output worker leaves. See footnote 15 for a related discussion.

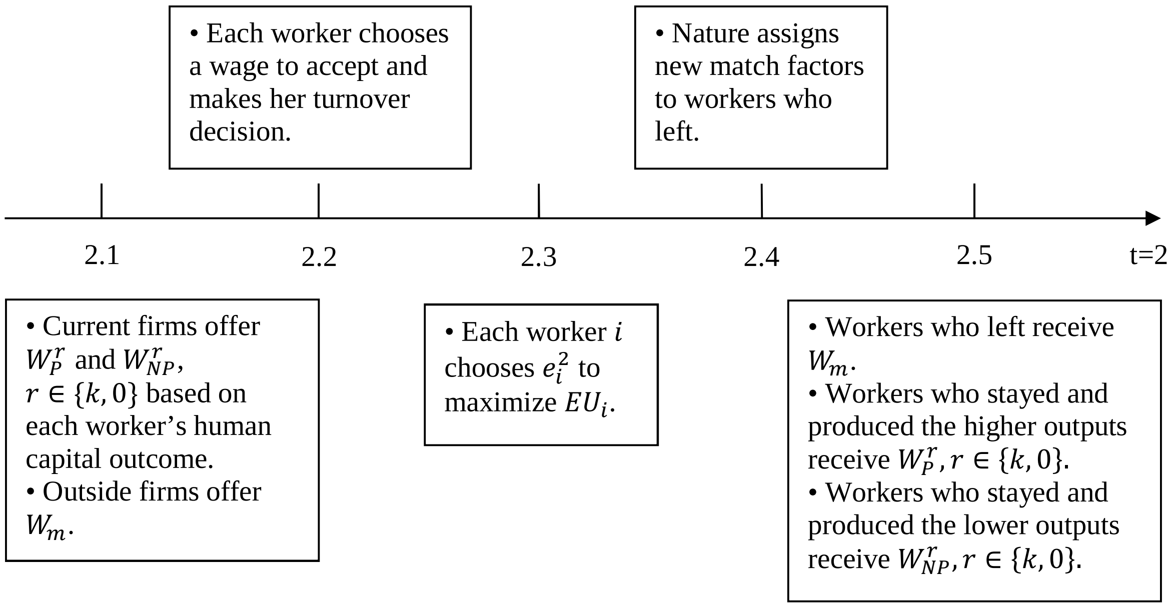

Figure 7. Timing of the Extended Tournament Model, Period 2

2.2. Analysis

Below let e_1^{**} and W_Y^{**} denote the first period effort level and wage in equilibrium, and e_2^{**} and W_m^{**} denote the second period levels. Also, define $\rho \equiv 1 - \frac{k}{a}$.[45] The analysis of the extended tournament model is summarized in Proposition 2.1.

<u>Proposition 2.1:</u>

i) In period 1, the equilibrium effort level e_1^{**} is below the efficient level, i.e., $e_1^{**} < e_1^S$, and the wage offer to the young workers W_Y^{**} satisfies the firm's zero profit condition.

ii) In period 2, each worker exerts zero effort, i.e., $e_2^{**} = 0$, and receives a market wage of $W_m^{**} = b$ in equilibrium if they switch employers.

[45] Note that due to the assumption that $0 < k < a$, $0 < \rho < 1$.

iii) In period 2, the wage offers to the old workers satisfy the following relationships: $W_P^0 > W_P^k > b > W_{NP}^k > W_{NP}^0$. Also, $W_P^k - W_{NP}^k = \rho(W_P^0 - W_{NP}^0)$, where $0 < \rho < 1$.

iv) If k is sufficiently small, the equilibrium turnover rates of the promoted and the non-promoted workers satisfy $P_P^k > P_P^0$ and $P_{NP}^k < P_{NP}^0$.

Proposition 2.1 says several things. First, the equilibrium effort level is below the efficient level of effort. Following the same intuition as in the tournament model analyzed in the first chapter of my dissertation, the intuition behind the first point is that the second period wages serve both the roles of eliciting first period effort and determining the turnover rates of the promoted and non-promoted workers. As a result, effort is lower than the efficient level because the wage spread is constrained by the need to minimize inefficiencies from turnover.

Second, given the human capital outcome, the promoted workers earn higher wages than the non-promoted workers. The reason is that the wage difference between the promotion and the non-promotion wages serves as an incentive for each worker to exert effort. In addition, the wage spread is smaller for the human capital workers. The reason is that the workers with the human capital contribute more to the productivities at the firm, and thus each firm has a stronger incentive to minimize the inefficiencies from turnover for the human capital workers. As a result, the wage spread is lower under the human capital case. This analysis leads to my last point. That is, compared to the non-human capital workers, the human capital workers have a higher turnover rate if they are promoted and a lower turnover rate if not.

2.3. Testable Implications

I now discuss testable implications from Proposition 2.1.

Corollary 1.1': Across the economy, there are large wage increases upon promotion (Test 1).

Corollary 1.1 follows immediately from Proposition 2.1, part iii) since promoted workers earn higher wages than non-promoted workers regardless of the human capital outcomes. Note that this positive relationship also holds after controlling for performance ratings because given output fixed, it is still true that promoted workers earn higher wages than non-promoted workers.[46]

Corollary 1.2': Across the economy, workers with higher outputs are more likely to be promoted (Test 2).

Identical to Corollary 1.2, Corollary 1.2' is more of an inherent assumption of the tournament model than a result. See Corollary 1.2 for a related discussion.

Corollary 1.3': When k is sufficiently small, the turnover rates of the promoted and non-promoted workers satisfy the following relationships, i.e., $P_P^r < P_S^r < P_{NP}^r$, $r \in \{k, 0\}$; the wage is negatively related to turnover controlling for promotions (Test 3).

Corollary 1.3' follows from Proposition 2.1, part iii). Given the human capital outcome, the promoted workers have strictly lower turnover rates than the non-promoted workers. That is, promotion is negatively correlated with turnover. Note that the firm specific human capital needs to be sufficiently small for the above conclusion to hold. The reason is that when the human capital is large, each firm will have an incentive to keep all the workers with the human capital

[46] Note than when firm specific human capital is added, the tournament model's prediction concerning the relationship between performance ratings and wages controlling for promotions becomes ambiguous. The reason is that the relationship between the human capital and non-human capital wages differs by the promotion outcomes. Specifically, the human capital wage is higher for the promoted workers yet it is lower for the non-promoted workers. Given that the human capital workers have higher outputs, the ambiguous wage relationships lead to an ambiguous relationship between performance ratings and wages.

from leaving independent of whether or not the worker is promoted. As a result, there will be no turnover in equilibrium.

In addition, the wage is negatively correlated with turnover controlling for promotions. The intuition here is that a worker compares the net benefit of staying to the net cost of staying when she makes her turnover decision. The net benefit of staying equals the difference between the current firm's wage offer and the market wage, while the net cost of staying is a function of the realized match quality. Therefore, the higher the wage difference, the less likely the worker will leave. Given that workers with different human capital outcomes earn different wages from the current firm but the same market wage, there exists wage dispersion after controlling for the job assignment. As a result, controlling for the job assignment, wage is negatively related to turnover in this extended tournament model.[47]

3. Extension of the Job Assignment Model with Firm Specific Human Capital

In this subsection I enrich the job assignment model in the same fashion as I did the tournament model to generate within job wage dispersion. This extension generates a negative relationship between wage and turnover controlling for promotions.

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[47] Note that the current model does not shed light on the relationship between promotion and turnover controlling for wages. The reason is that, given the current setting of the model, it is theoretically possible that a human capital worker who is not promoted earns the same wage as a non-human capital worker who is promoted. However, given the assumption that the human capital is a fixed amount, this is unlikely to occur in equilibrium. One way to generate such a prediction is to allow the human capital when there is a positive outcome to vary instead of being a fixed amount.

3.1. The Model

Same as the original setting of the model, there are two types of workers and each worker lives for two periods. Also, each firm hires n, $n > 0$, workers. Each worker i's innate ability θ_i is either high or low, $\theta_i \in \{\theta_L, \theta_H\}$, and the proportion of high ability workers, denoted by $\rho \in (0,1)$, is common knowledge. There are two types of jobs in each period, where the productivity of each worker i at job j in period t, y_{ijt}, depends on both ability and a stochastic term, i.e., $y_{ijt}^0 = d_j + c_j(\theta_i + \varepsilon_{ijt})$, where $j \in \{1,2\}$ and $t \in \{1,2\}$. Also, job 2 is more sensitive to abilities in the sense that the return to ability is higher at job 2. Moreover, there is complete information concerning outputs, incomplete information concerning ability on both sides of the market, and symmetric learning of ability so that at any point in time, all participants of the game are equally informed of it through observing the outputs.

What is new to this extension is the introduction of firm specific human capital. Specifically, assume each worker has a probability δ of accumulating firm specific human capital k in period 1. Moreover, if the worker accumulates the human capital, her productivity at the current firm becomes $y_{ijt}^k = k + d_j + c_j(\theta_i + \varepsilon_{ijt})$, where $j \in \{1,2\}$ and $t \in \{1,2\}$.[48] Further, assume there is symmetric learning of the human capital among firms in the sense that all firms observe whether a worker accumulates the human capital or not.

Assumptions on the match factor remain exactly the same as in the tournament model. Specifically, for each worker i, there is a match factor α_i, which follows a uniform distribution on the interval $[-a, a]$, where $a > 0$. The match factor is both firm and worker specific and there

[48] Alternatively, one can introduce the human capital multiplicatively into the production functions. Such a change would have no qualitative effects on the predictions of the job assignment model.

is asymmetric learning of the match factor so that the realization of a match is only observable to the worker. As discussed in the tournament section, because firms are unable to tell good matches from bad ones, the worker with a sufficiently bad match is not fully compensated for it and leaves. In addition, the same as in the original model, I assume there is an employer-switching cost, denoted by s, which is strictly positive and constant across firms and workers. In order for there to be strictly positive equilibrium turnover, I restrict s to be in the interval $(0, a)$. As a result, it is efficient for a worker without firm specific human capital to leave when the disutility from her match with the current firm is higher than the employer switching cost. In addition, assume the realization of the match factor and the human capital accumulation are independent. Finally, I assume both workers and firms are ex-ante homogeneous and risk neutral, and there is free entry into the market as well as a zero discount rate.

The timing of the game is the following. At the beginning of each period, firms simultaneously make wage offers based on each worker's expected productivity. Each worker then chooses the highest wage offer to accept and makes her turnover decision to maximize her expected utility. At the beginning of the second period when there are multiple firms tied at the highest expected utility, I assume each worker randomly picks a wage offer to accept unless one of these came from the worker's previous employer, in which case the worker chooses to stay with that firm.

Specifically, at the beginning of period 1, each firm makes a wage offer W_Y to young workers, while each worker picks the highest wage offer to accept. During period 1, nature assigns a match factor to each worker, which is drawn from the uniform distribution defined previously, as well as the realization for firm specific human capital. At the end of period 1, all firms (and the worker in question) simultaneously observe each worker's first period output and update their beliefs concerning the worker's ability. In addition, each firm observes the human capital outcomes of all workers. In the meantime, each worker observes the realization of her match and gets paid the first period wage. At the beginning of the second period, each worker i's current employer offers her a second period wage denoted by W_i^r where $r \in \{k, 0\}$, while outside firms offer her a market wage denoted by W_i^m. These wage offers are made based on their updated beliefs regarding the worker's expected ability, denoted by θ_i^e. Each worker then makes her turnover decision based on a comparison of the cost and the benefit from staying. If a worker leaves, nature assigns a new match factor to her which is drawn from the same distribution and is independent of the previous draw. Finally, at the end of period 2, each firm pays second period wages.

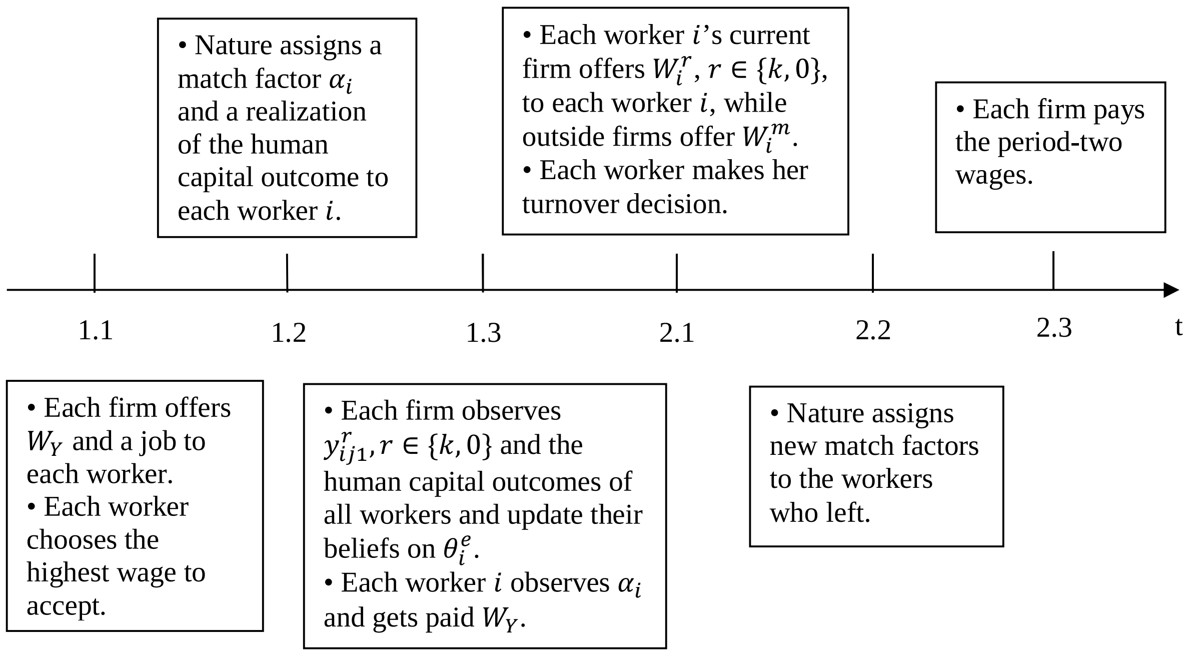

Figure 8. Timing of the Extended Job Assignment Model

3.2. Analysis

This subsection analyzes the model following a logic similar to the one in the original analysis. To begin, let $1(k > 0)$ be an indicator function for the realization of the firm specific human capital whose value equals 1 if a worker attains the human capital in period 0, and 0 otherwise. Also, let z_{1t} denote the labor market signal the firms extract regarding the worker's expected ability at the end of period 1. Because each firm observes the human capital perfectly at the end of the first period, the signal each firm extracts is independent of the human capital outcomes, i.e., $z_{1t} = \frac{y_{1jt}^{r} - d_j - 1(k>0)k}{c_j} = \theta_i + \varepsilon_{1jt}, r \in \{k, 0\}$. As a result, the ability signal does not vary with the job assignment or human capital outcomes. Let θ_i^e denote each worker i's expected ability at the end of period 1, i.e., $\theta_i^e = E(\theta_i | z_{1t})$. Lastly, since the human capital contributes to the productivities of both jobs equally, it has no impact on firms' promotion decisions.

I now define the average ability level of the young workers and the efficient ability level for promotion. Following the notation in Chapter 1's job assignment model, let $\bar{\theta}$ and $\tilde{\theta}$ denote the average ability level of the young workers and the critical ability level for promotion, respectively. The same as in the original model, the average ability level of the young workers $\bar{\theta}$ satisfies the following condition, i.e., $\bar{\theta} = \rho\theta_H + (1 - \rho)\theta_L$. Additionally, because the human capital contributes equally to the productivities at the two jobs, each firm's promotion decisions are independent of the human capital outcomes. Therefore, the critical ability level for promotion is also independent of the human capital accumulation. That is, $\tilde{\theta}$ satisfies the condition $d_1 + c_1\tilde{\theta} = d_2 + c_2\tilde{\theta}$.

We now solve the utility maximization problem with respect to each worker i. Consider the second period problem first. Because the outside firms do not benefit from the firm specific human capital, their decisions do not depend on the human capital outcome. Let W_i^m denote the market wage offer. The previous analysis tells us that W_i^m equals worker i's expected second period productivity at an outside firm, i.e., $W_i^m = E(y_{ij2}|k = 0)$. On the other hand, the current firm's wage offer to each worker i varies with her human capital outcome. Specifically, because a worker would produce a higher output if she accumulated the human capital, the current employer of this worker has an incentive to offer her a higher wage if she attained the human capital in order to decrease her probability of switching employers. Let W_i^k and W_i^0denote the wages each worker i's current employer offers if she attains and does not attain the human capital, respectively. The analysis above tells us $W_i^k > W_i^0, \forall i$.

We now solve for the second period wages explicitly. Similar to the analysis in the original model, each firm extracts rents from the good matches of their current employees. Specifically, each firm chooses a wage difference to maximize its expected second period profit from each worker. Because the human capital contributes the same amount of output to the two jobs, job assignment should have no impact on the rent each firm extracts from a worker. Let Δ_i^r denote the difference between the turnover and non-turnover wages each worker i receives given her human capital outcome r, i.e., $\Delta_i^r = W_i^m - W_i^r$, where $r \in \{k, 0\}$. If worker i does not accumulate the human capital, the problem stays exactly the same as in the original model. That is, Δ_i^0 satisfies $\Delta_i^0 = \frac{a+s}{2}$ in equilibrium. On the other hand, if worker i accumulates the human capital, the firm's second period profit function is given by $E\Pi_i^k = P(\alpha_i \leq s - \Delta_i^k)[E(y_{ij2}^k) - W_i^k]$, where $E(y_{ij2}^k) = W_i^m + k$. Therefore, we can rewrite the expected profit function as

$E\Pi_i^k = P\left(\alpha_i \leq s - \Delta_i^k\right)(\Delta_i^k + k)$. Given that $\alpha_i \sim U[-a, a]$, $E\Pi_i^k$ can be expressed as $E\Pi_i^k = \frac{s+a-\Delta_i^k}{2a}(\Delta_i^k + k)$. Taking the first order condition of the profit function with respect to Δ_i^k we have $\Delta_i^k = \frac{s+a-k}{2}$.[49] From the solution to the wage difference Δ_i^r we can see that given the human capital outcome, the wage difference is independent of the job assignment. Therefore, the human capital outcomes exert no distortion on the promotion decisions, i.e., a worker is promoted to the high level job in period 2 if her expected ability is above the critical value $\tilde{\theta}$ and remains at the low level job otherwise.

Based on the solution to the wage difference Δ_i^r we now can express the equilibrium wages explicitly. Consider first the market wages. If $\theta_i^e > \tilde{\theta}$, worker i is promoted to the high level job and earns a market wage of $W_i^m = d_2 + c_2\theta_i^e$. On the other hand, if $\theta_i^e \leq \tilde{\theta}$, worker i stays at the low level job and gets a market wage of $W_i^m = d_1 + c_1\theta_i^e$. Given the market wages above, the current firm's wage offer to each worker i satisfies $W_i^r = W_i^m - \frac{a+s-1(k>0)k}{2}$, where $r \in \{k, nk\}$.

Based on the second period wages, we can now characterize the equilibrium turnover rates. Let P^r denote the equilibrium turnover rate of the workers with the human capital outcome r, where $r \in \{k, nk\}$. Since each worker makes her turnover decision based on a comparison of her match quality with the summation of the wage difference and the employer switching cost, we know $P^{nk} = \frac{3a-s}{4a}$ and $P^k = \frac{3a-s-k}{4a}$. Consistent with my previous conjecture, workers with the human capital have lower turnover rates than workers without the human capital in equilibrium. Last but not least, the equilibrium first period wage satisfies the zero profit constraint,

[49] Note that $\Delta_i^k > 0$ in equilibrium due to the assumptions that $0 < k < a$ and $s > 0$.

$W_Y^{**} = d_1 + c_1\bar{\theta} + \delta\frac{(a+s+k)^2}{8a} + (1-\delta)\frac{(a+s)^2}{8a}$. As a result, each firm pays a young worker a higher wage than her expected output in the first period because of the rent extraction in the second period.

The previous analysis is summarized in Proposition 2.2.

Proposition 2.2:

i) In period 1, all young workers are assigned to job 1 and paid the first period wage, $W_Y^{**} = d_1 + c_1\bar{\theta} + \delta\frac{(a+s+k)^2}{8a} + (1-\delta)\frac{(a+s)^2}{8a}$.

ii) In period 2, a worker with the expected ability $\theta_i^e > \tilde{\theta}$ is promoted to job 2, receives a second period wage of $W_i^k = d_2 + c_2\theta_i^e - \frac{a+s-k}{2}$ if she accumulates the firm specific human capital and $W_i^{nk} = d_2 + c_2\theta_i^e - \frac{a+s}{2}$ otherwise; whereas a worker with the expected ability $\theta_i^e \leq \tilde{\theta}$ remains at job 1 (see footnote 28), receives a second period wage of $W_i^k = d_1 + c_1\theta_i^e - \frac{a+s-k}{2}$ if she accumulates the firm specific human capital and $W_i^{nk} = d_1 + c_1\theta_i^e - \frac{a+s}{2}$ otherwise.

iii) The equilibrium turnover rate of the workers with the firm specific human capital equals $P^k = \frac{3a-s-k}{4a}$ while that of the workers without the human capital equals $P^{nk} = \frac{3a-s}{4a}$.

Proposition 2.2 tells us several things. First, for each worker i, $W_i^k > W_i^{nk}$. That is, workers with the human capital earn strictly higher wages than those without it. Moreover, as is shown in Proposition 2.2, part i), the first period wage is strictly above young workers' expected productivity. The reason is that each firm extracts strictly positive rents from its employees in the second period. Because the first period wage satisfies the zero profit condition, it is higher than a young worker's expected productivity in the first period.

Additionally, let R_r^* denote the rent extracted in equilibrium from the workers with the human capital outcome $r, r \in \{k, 0\}$. We know that $R_r^* = E\left(y_{ij2}^r\right) - W_i^r, r \in \{k, 0\}$. That is, $R_k^* = \Delta_k^* + k$ and $R_0^* = \Delta_0^*$. Based on the solutions to Δ_r^*, we know $R_k^* > R_0^*$ and $E\Pi_i^k > E\Pi_i^0$. That is, each firm extracts more rent from the workers with the human capital and hence makes higher expected profit.

Furthermore, as is stated in Proposition 2.2, part iii), the human capital workers have lower equilibrium turnover rates. The reason is that the difference between the turnover wage and the non-turnover wage for a human capital worker is higher due to the higher wage she receives at her current employer.

In addition, given the human capital outcome, turnover is independent of the job assignment. The intuition behind this point is that the wage difference between the turnover and the non-turnover wages is the same among the workers with the same human capital outcome.

As a final point, Proposition 2.2, part ii) says that there exists a strictly positive probability τ that a promoted worker without the human capital earns the same wage as a non-promoted worker with the human capital.[50]

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[50] Specifically, there exists an ability interval such that for each non-human capital worker who is promoted with an expected ability in this interval, there exists a human capital worker who is not promoted with an ability that is $\frac{k}{2}$ lower than the first worker yet earns the same second period wage as the promoted worker. Moreover, the interval can be expressed as $(\tilde{\theta}, \max\left\{\tilde{\theta} + \frac{k}{2}, \theta_H\right\})$ and $\tau = P(\tilde{\theta} < \theta_i < \max\left\{\tilde{\theta} + \frac{k}{2}, \theta_H\right\})$, where the probability is defined based on the distribution of ε_{ijt}.

3.3. Testable Implications

We now derive testable implications from Proposition 2.2.

Corollary 2.1': Promotions are positively related to wage increases without controlling for performance ratings while they have no impact on wage increases controlling for performance ratings; performance ratings are positively related to wage increases controlling for promotions (Test 1).

Similar to the discussion following Corollary 2.1, because workers who are promoted are on average of higher expected productivities, they also earn higher wages than the non-promoted workers. Moreover, since wages are determined by expected productivities in the job assignment model, controlling for performance ratings, promotion has no significant impact on wage increases. However, when performance ratings are coarse, workers with the same performance rating might be of different expected productivities and hence job assignments. As a result, promotions will be positively correlated with wage increases controlling for performance ratings if the ratings are coarse.[51] Lastly, performance ratings are positively related to wage increases controlling for promotions. This is because, given the job assignment, workers with higher expected productivities earn strictly higher wages.

Corollary 2.2': The probability of promotion weakly increases with performance ratings (Test 2).

Similar to the argument in Corollary 2.2, because a worker whose expected ability is higher than the cutoff ability level $\tilde{\theta}$ is promoted while one whose expected ability is lower than the cutoff level remains at the low level job in period two, a worker is only promoted if her expected

[51] See Corollary 2.1 for a related discussion.

output reaches a certain cutoff level. As a result, the probability of promotion follows a step function of performance ratings. [52]

Corollary 2.3': On average, across workers with different human capital outcomes, promotion is not related to turnover, while promotion is positively related to turnover controlling for the wage; wage is negatively related to turnover controlling for promotions (Test 3).

Proposition 2.2, part iii) tells us that turnover only varies with the human capital outcome and hence is independent of job assignment. Because the realization of the human capital outcome is independent of ability, without controlling for the wages, promotion is not related to turnover. On the other hand, due to the possibility that a promoted worker without the human capital earns the same wage as a worker who is not promoted but has the human capital and the fact that the human capital workers have a lower turnover rate, the model further predicts that controlling for the wages there is a positive relationship between promotion and turnover. Finally, the further extended job assignment model predicts that controlling for promotions, wage is negatively related to turnover. The logic behind this prediction is that workers with the human capital both earn higher wages and have a lower turnover rate.[53]

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[52] As in the original case, promotion follows a step function of expected outputs in this further extended model. What changes is that now there are two critical output levels, one for the workers with the human capital and the other for the workers without it. In more detail, if a worker's output is above the first critical point, she is promoted with probability 1. If her output is between the two critical levels, she is promoted if she does not accumulate the human capital. Lastly, if her output is below the second critical level, she is not promoted with probability 1.

[53] In fact, the negative relationship between wage and turnover also holds without controlling for promotions. Because turnover is independent of the job assignment, whether or not promotion is controlled for does not alter the wage and turnover dynamics.

4. Conclusion

In this chapter, I further extend both tournament theory and job assignment theory with productivity enhancing firm specific human capital. The purpose of each extension is to generate within-job wage dispersion to allow each theory to make predictions regarding the wage and turnover dynamics controlling for promotions. Extending the two models in this way yields that each model predicts that wage is negatively correlated with turnover controlling for promotions.

CHAPTER 3

EVIDENCE ON PROMOTION AND TURNOVER

1. Introduction

Following the previous chapters of my dissertation, this one tests the empirical predictions derived from the tournament model, the job assignment model, and the signaling model as well as the extensions of the first two models with firm specific human capital. Recall from the first chapter that each theory makes three predictions regarding wage, promotion, and turnover dynamics. The first two predictions are the same across the three theories, and the third prediction distinguishes among them. Specifically, all three theories predict that promotions are positively related to wages, and that output is positively related to the probability of promotion. As for the promotion and turnover dynamics, tournament theory predicts that promotion is negatively related to turnover, job assignment theory predicts that promotion is not related to turnover, while signaling theory predicts that promotion is positively related to turnover given certain conditions. In the second chapter, I further extended both the tournament model and the job assignment model with firm specific human capital. As a result of the extension, the tournament model predicts that promotion is negatively correlated with turnover, controlling for wages. On the other hand, the job assignment model predicts that promotion is positively related to turnover controlling for wages. That is, with the introduction of human capital, the direction of the promotion-turnover relationship changes from being insignificant to positive for the job assignment model. In addition, both models predict that wage is negatively related to turnover controlling for promotions.

I test these predictions using a dataset from a single firm in the financial services industry in the U.S. The data were first collected and analyzed in Baker, Gibbs, and Holmstrom (1994a, 1994b) (hereafter, the BGH dataset). In my analysis of the full sample, I find that both promotion and performance ratings are positively related to wage levels, and that performance ratings are positively related to the probability of promotion. Moreover, promotion has no significant impact on turnover. Lastly, turnover is decreasing in wages controlling for promotions. Comparing these results to the theoretical predictions, it seems that job assignment theory without firm specific human capital best captures the empirical findings concerning the full sample.

To explore the theoretical predictions further, I divide the data into subsamples where the samples differ in terms of which job level the worker was on in the period of the observation. The logic behind this approach is twofold. To begin, the classic paper of Baker, Jensen, and Murphy (1988) on firm hierarchies suggests that tournament theory is likely to be more applicable in jobs in which incentives are relatively important. In the empirical analysis, I use job level as a proxy for the importance of incentives. Building on Rosen (1982), the idea is that incentives to induce higher effort should become more critical as the job level increases, as the return to effort likely increases with job level. This argument suggests that tournament theory should be more applicable in higher level jobs. Building on an argument of Rosen (1986), the hybrid approach of tournament theory and signaling theory discussed in Waldman (2013) provides another explanation for why the promotion-turnover dynamics might vary with job level. Specifically, by incorporating high market wage offers due to promotion signaling as constraints in a classic tournament setting, Waldman (2013) argues that tournament theory is more likely to hold in higher level jobs while signaling theory is more likely to hold in lower level jobs. The reason is that the constraints on promotion wages in tournaments due to market wages and signaling are more likely to be binding at lower level jobs.

Consistent with the full sample results, the subsample results provide further evidence in support of the positive relationship between promotions and wages and that between performance ratings and the probability of promotion. Moreover, I find that promotion is negatively related to turnover in the high level subsample, while it is positively related to turnover in the low level subsample. Consistent with the conjecture of both the incentive argument building on Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach of Waldman (2013), these results suggest that tournament theory with firm specific human capital better describes the role of promotion among higher level jobs, while signaling theory better captures the role of promotion among lower level jobs.[54, 55]

The subsample findings discussed above also provide more insight into the interpretation of the full sample results. Recall that tournament theory predicts a negative relationship between promotion and turnover, while signaling theory predicts a positive relationship between promotion and turnover when certain conditions are met. Therefore, instead of interpreting the full sample results as evidence consistent with the job assignment model without human capital, it seems more plausible to interpret these results as suggesting that the incentive role and the signaling role of promotions seem to coexist in the BGH data. That is, the full sample findings provide further evidence consistent with the incentive argument based on Rosen (1982) and Baker, Jensen, and Murphy (1988) as well as the hybrid approach of Waldman (2013).

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[54] Note that the incentive argument is silent on the role of promotion in lower level jobs.

[55] According to Baker, Gibbs, and Holmstrom (1994a), firm specific human capital seems to be not prevalent at the firm in their study. Therefore, it seems more likely that the signaling model captures the underlying dynamics of promotion and turnover in the dataset I study.

The contributions of this chapter are twofold. First, I show clear evidence of the relationship between promotion and turnover using data from a representative firm in the financial services industry in the U.S. Second, I describe the conditions under which each theory better matches the empirical evidence.

The outline of this chapter is as follows. Section 2 offers a brief literature review. Section 3 reviews the testable implications of each theory. Section 4 describes the data. Section 5 presents the empirical analysis. Section 6 concludes.

2. Related Empirical Literature

This section reviews the related empirical literature. To begin, a number of empirical studies have found evidence consistent with the existence of large wage increases upon promotion. These studies include but are not limited to Murphy (1985), Lazear (1992), Baker, Gibbs, and Holmstrom (1994a, 1994b), and McCue (1996). In addition, there is rich empirical evidence that high performance ratings today predict good outcomes in the future. Specifically, both Medoff and Abraham (1980, 1981) and DeVaro and Waldman (2012) find that performance ratings are positively related to future promotions and wage increases.[56]

However, the empirical evidence on the relationship between promotion and turnover is decidedly mixed. Within the field of economics, one of the most relevant studies is Dias da Silva and van der Klaauw (2011), who study returns to job transitions using Portuguese matched employer-employee data. One of their major findings is that promotions have no significant impact on turnover. Outside the field of economics, several human resource studies also shed

[56] See Waldman (2012) for a detailed discussion of the aforementioned papers.

light on the manner in which promotion and turnover interact. For example, Trevor, Gerhart, and Boudreau (1997) explore the relationship between performance ratings and voluntary turnover using a single-firm dataset and conclude that promotion significantly increases voluntary turnover. They further find that this positive effect is more pronounced for poor performers. Another example is Saporta and Farjoun (2003), who investigate how promotion affects turnover and how this effect varies with occupations using a longitudinal dataset from a single firm. They find that promotion decreases turnover regardless of occupation.

My paper is different from these studies mainly in five ways. First, the focus of the papers differs. I focus on how promotion affects turnover and how such interactions vary with job level. On the other hand, Trevor, Gerhart, and Boudreau focus on how performance ratings interact with turnover, while Saporta and Farjoun stress how the promotion-turnover dynamics vary with occupation. Second, my study differs from the aforementioned studies in terms of the approaches. For example, neither of the human resource studies control for both job level and education, which turn out to be key to the understanding of the promotion-turnover relationship. Third, in contrast to Trevor, Gerhart, and Boudreau (1997) and Dias da Silva and van der Klaauw (2011), I control for wage increases upon promotion in my study of the promotion and turnover dynamics.[57] Fourth, my paper differs from those studies in terms of the empirical findings. Instead of the positive relationship Trevor, Gerhart, and Boudreau find, I find that promotion is unrelated to turnover when I focus on the full sample. Moreover, I find that how promotion affects turnover varies with job level, which is novel to my study. Specifically,

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[57] Because promotions are often accompanied by significant wage increases, taking wage increases into account is important for getting a true estimate of the impact of promotion on turnover as opposed to the combined effect of promotion and the wage increases associated with promotions.

promotion is negatively correlated with turnover in higher level jobs while it is positively correlated with turnover in lower level jobs. Fifth, in contrast to both of the human resource studies, I focus more on economic theories rather than psychological explanations concerning promotion-turnover interactions.[58]

3. Review of Testable Implications

This section offers a brief review of the three sets of testable implications derived from tournament, job assignment, and signaling theories.[59] To begin, all three theories predict that wages are positively related to promotions. In terms of tournament theory, this prediction is in a sense an inherent assumption of the promotion scheme. Job assignment theory makes such a prediction because workers who are promoted are of higher expected abilities and are assigned to the job in which they are more productive. Signaling theory predicts a positive correlation between wage and promotion because promotion sends out a positive signal to outside firms regarding the worker's high ability and hence market wage offers bid up the wage the worker receives after the promotion.

Besides the positive relationship between wage and promotion, all three theories predict that performance ratings are positively related to the probability of promotion. Tournament theory makes such a prediction due to the assumption that workers are promoted according to the rank order of their outputs. On the other hand, job assignment theory and signaling theory predict such a positive relationship between performance ratings and the probability of promotion

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[58] Note than none of the psychological explanations fully capture the empirical evidence I find. Specifically, none of them explains the finding that the promotion and turnover dynamics vary with job level.

[59] See "Theory on Promotion and Turnover" and "Theoretical Extensions on Promotion and Turnover" for details. See also Table 1 for the summary of the predicted correlations of all the theories.

because in both theories, workers revealed to be of high ability are promoted and firms learn from observing performance ratings.[60]

Even though the first two predictions are the same among the theories, the one regarding promotion and turnover dynamics distinguishes among them. Specifically, tournament theory predicts that promotion is negatively correlated with turnover. The intuition behind this prediction is that there is a wage premium associated with promotion which is only available at the current employer of each worker. In order to earn the wage premium, a promoted worker has to stay with her current employer. As a result, there is a negative relationship between promotion and turnover according to the tournament model. However, due to the lack of within job wage dispersion, the tournament model makes no prediction regarding the relationship between wage and turnover controlling for promotions.

On the other hand, the job assignment model predicts that promotion is not related to turnover. The logic behind this prediction is that the difference between the turnover and non-turnover wages is the same among workers and hence is independent of the job assignment. As a result, promotion is not related to turnover with or without controlling for wages. In addition, because turnover is the same among workers and hence is independent of ability, the wage is unrelated to turnover controlling for promotions.

The signaling model makes the prediction that when the return to effort is similar at different jobs and when firm specific human capital is small, promotion is positively related to turnover. The intuition behind this prediction is threefold. First, because the difference between the turnover and non-turnover wages increases with the distance between a worker's realized ability

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[60] Note that I use performance rating as a proxy of output in the interpretation of all the testable implications.

and expected ability-what I call the ability distance-the turnover rate decreases with this distance. Second, when return to effort is similar among the jobs, turnover decreases with the ability distance in a similar fashion at all jobs. Third, when firm specific human capital is small, the proportion of promoted workers is small. As a result, the average distance between the realized and expected abilities is smaller for the promoted workers. Therefore, the turnover rate of the promoted workers is higher than that of the non-promoted workers. That is, promotion is positively related to turnover.

In addition, the signaling model predicts that the wage is negatively correlated with turnover given promotion. The idea here is that the difference between the turnover and non-turnover wages increases in the ability distance given the job assignment. Because turnover decreases in the ability distance, given promotion, we should expect to see that wage is negatively associated with turnover.

When firm specific human capital is introduced, both the tournament and the job assignment models make new predictions regarding the relationships between wage, promotion, and turnover. To begin, as previously, the tournament model with firm specific human capital predicts that promotion is negatively correlated with turnover controlling for wages. Similar to the intuition in the original extension of the model, workers who are promoted only earn the high wages if they stay with their current employers. As a result, there is a negative correlation between promotion and the probability of leaving.

On the other hand, the job assignment model with human capital predicts that promotion is positively related to turnover controlling for wages, which is different from the job assignment model with no human capital. The idea behind this prediction is that, because workers with the human capital have higher expected productivities at their initial employers, each firm pays higher wages to these employees to increase their probabilities of staying. As a result, the workers with the human capital have a lower turnover rate than the workers without it. Because it is theoretically possible for a human capital worker with low ability who is not promoted to earn the same wage as a non-human capital worker with high ability who is promoted, job assignment theory predicts that, controlling for wages, there is a positive relationship between promotion and turnover.

Another new result is that both the tournament and the job assignment models with human capital predict that wage is negatively associated with turnover controlling for promotions. The reason is that workers with different human capital outcomes earn different wages upon promotion. However, all workers receive the same market wage offer due to the fact that the human capital is firm specific. Because each worker makes her turnover decision based on a comparison of the wage gain from staying to the match quality, workers with higher wages have a higher probability of staying. Therefore, both the enriched tournament and job assignment models predict that there is a negative relationship between wage and turnover controlling for promotions.

Table 1 summarizes the predicted correlations from all three theories and the associated theoretical extensions. As has been reviewed in this section, the three theories make similar predictions regarding the relationship between promotions and wages and that between performance ratings and the probability of promotion.[61] Therefore, the theories mainly differ in their predictions on the promotion and turnover dynamics. Specifically, tournament theory

[61] Note than when firm specific human capital is added, the tournament model's prediction concerning the relationship between performance ratings and wages controlling for promotions becomes ambiguous. See footnote 46 for a related discussion.

predicts that promotion is negatively related to turnover, job assignment theory predicts that promotion is not related to turnover, while signaling theory predicts that promotion increases turnover given certain conditions hold. In addition, tournament theory and job assignment theory enriched with firm specific human capital predict a negative relationship between wage and turnover controlling for promotions.[62]

4. Data

My data consist of personnel records of all managerial employees of a medium-sized firm in the financial services industry in the U.S. over the years 1969-1988. They were first collected and analyzed in the seminal studies of Baker, Gibbs, and Holmstrom (1994a, 1994b) and originally contained information on 16,133 unique employees over twenty years. All told, the dataset contains 74,071 employee-year observations and individual information on gender, race, age, education, salary, tenure, performance ratings, and turnover.

One unique feature of the BGH dataset is its simple and well-constructed hierarchical levels. Specifically, the data can be grouped into eight job levels, the construction of which is purely based on the pattern of transitions between job titles.[63] The rigid hierarchical structure is convenient in defining promotions. Based on the eight job levels above, I construct a 0/1 indicator variable for promotion, whose value is 1 if the job level in the contemporaneous year is higher than that in the previous year. Similar to DeVaro and Waldman (2012), I do not distinguish between single-level promotions and multiple-level promotions. This is unlikely to

[62] Note that when enriched with human capital, job assignment theory predicts a positive relationship between promotion and turnover instead of the zero relationship it predicted given no firm specific human capital.
[63] See Baker, Gibbs, and Holmstrom (1994a) for a more complete discussion of the construction of job levels.

cause any problem because 97.44% of the promotions in the BGH dataset are single-level promotions.[64]

Another advantage of the BGH dataset is that it contains complete records of individuals' career histories, including salary and turnover. I define turnover based on the variable "year-to-quit." "Year-to-quit" measures the number of years until a worker leaves the firm since the end of the previous year. For example, if "year-to-quit" equals 3 in 1980, it means that the individual left the firm in 1982. Therefore, for individuals who leave by the end of the contemporaneous year, "year-to-quit" equals 1. Further, for individuals who never leave during the twenty-year span, "year-to-quit" is recorded as missing for each year during the period of observation. Based on the variable "year-to-quit," I construct a 0/1 indicator variable for turnover, whose value equals 1 if "year-to-quit" is 1, and 0 otherwise (where 0 includes missing values of "year-to-quit").[65]

Another key variable in my study is compensation. To measure compensation, I use real annual salary measured in 1988 dollars. Further, performance ratings are measured on a 5-point scale in a descending order, i.e., a performance rating of 1 denotes the best performance, while that of 5 denotes the worst. Finally, for those variables whose values change on a yearly basis, such as performance rating, promotion, and job level, I use their values from the previous year instead to ensure they each have at least a full-year of impact on each observation.[66]

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[64] I also ran all the tests on the sample without multiple-level promotions. I found no qualitative differences in the coefficients.
[65] Due to lack of information, I do not distinguish between quits and layoffs. Also, I have experimented with defining turnover to be 1 when an individual exits the dataset. The adoption of this alternative definition has no impact on the results.
[66] DeVaro and Waldman (2012) use a similar approach in their empirical analysis.

I now discuss the restrictions I employ in constructing my samples. First, because tenure is an important control variable in most of my regressions, I drop the 1969 cohort from the sample because their complete career paths prior to year 1969 are not available. To exclude retirements from the turnover sample, I drop the observations in which workers' ages are higher than 60.[67] I also restrict attention to male workers because previous studies find that the promotion dynamics between male and female workers might be different (e.g., Lazear and Rosen 1990). Additionally, I exclude those workers who work overseas because the compensation data are recorded in local currencies. Also, I restrict my attention to white workers. Finally, to keep the sample sizes across tests fairly constant, I drop all observations that contain missing values of salary, promotion, age, education, tenure, and job level. As a result, my full sample consists of 4,216 employees and 22,060 employee-year observations. Table 2 presents the descriptive statistics of the full sample, while Table 3 breaks down salary, change-in-salary, promotion, turnover, and performance rating by job level.

5. Empirical Analysis

This section discusses the empirical findings on the testable implications derived from the theory chapters. As a first step, I run the tests on the full sample. Here, I find that each theory is able to capture some of the empirical findings, though none of them describes the data perfectly.

To further examine the validity of the various theories, I then divide the full sample into subsamples according to job level. The logic behind this approach is twofold. To begin, tournament theory is likely more applicable to jobs in which incentives are relatively important,

[67] I have also experimented with other cutoff retirement ages such as 50 and 55. The results are robust to these other cutoff levels.

an insight built on the study of Baker, Jensen, and Murphy (1988). In seeking an explanation for why promotion serves as both an incentive device and a labor allocation device, Baker et al. consider promotion based incentive schemes and point out that there are costs associated with using promotions as incentives under certain conditions. Building on this insight, it seems plausible to assume that firms should only adopt tournament based incentive schemes in jobs in which incentives are particularly important.

When it comes to the empirical analysis, I use job level as a proxy for the importance of incentives because incentives are likely to be more important at higher job levels.[68] Rosen (1982) argues that return to ability increases with job level. According to this argument, if we were to take a standard approach according to which productivity is determined by the sum of ability and effort, it seems plausible to assume that return to effort should also increase with job level. Therefore, incentives to induce higher effort should become more critical as job level increases. My conjecture that firms are more likely to run tournaments in jobs in which incentives are more important suggests that tournament theory should fit the data better in jobs at higher levels.

A second motivation for my approach of splitting the full sample into subsamples by job level builds on a discussion in Waldman (2013). In comparing classic promotion tournaments and market-based tournaments, Waldman proposes a hybrid approach of the incentive role and the signaling role of promotion by incorporating market wage offers as a constraint into a classic tournament setting. Waldman (2013) then conjectures that the signaling model should be better at capturing the empirical evidence in lower level jobs while the tournament model should be better at capturing the evidence in higher level jobs. The intuition behind this conjecture is that

[68] Papers that have a similar setup include but are not limited to Garicano (2000) and Lemieux, Macleod, and Parent (2009).

the market wage is more likely to be binding at lower job levels because of the convex reward scheme argument of Rosen (1986). [69]

To separate the sample by job level, I group the jobs of levels 1 and 2 into a low level subsample and the jobs of levels 3 through 7 into a high level subsample, where the logic for this approach is further discussed at the beginning of the subsection that discusses the subsample results.[70] Table 4 presents the summary statistics of the level subsamples. Finally, I cluster standard errors by individual in all regressions because individual characteristics will frequently be serially correlated over time.[71]

5.1. Results from the Full Sample

This subsection presents the results of the tests using the full sample. As discussed earlier, previous studies have already found evidence consistent with the first two tests. For example, both Baker et al. (1994b) and McCue (1996) find that promotions are associated with wage premiums. Also, both Medoff and Abraham (1980, 1981) and DeVaro and Waldman (2012) find that performance ratings are positively related to the probability of promotion. Therefore, it is the test on promotion and turnover dynamics that clearly distinguishes this chapter from the previous studies. However, for completeness, I also report the results on the first two tests.

Below I present the results in the order of the derivation of the tests in the theoretical chapters. Let lnW_{it} denote worker i's annual compensation at the last day of year t, and $PROMOTION_{it}$

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[69] See Waldman (2013) for more detail.
[70] Note that in all the regressions the job levels are pre-promotion job levels.
[71] Standard errors barely change when they are not clustered by individual.

denote a 0/1 indicator variable whose value is 1 if worker i is promoted during year t. Further, let $rating_{it}$ denote worker i's performance rating in year t.

5.1.1. The relationship between promotions and wage levels (Test 1)

To study wage and promotion dynamics, I consider the following regression specification.

$$lnW_{it} = \alpha_0 + \alpha_1 promotion_{it} + \alpha_2 lnW_{i,t-1} + \alpha_3 rating_{i,t-1} + X_{it}\alpha_4 + Z_{i,t-1}\alpha_5 + \varepsilon_{it} \quad (1)$$

where X_{it} denotes a vector of individual characteristics in the contemporaneous year including age, education, tenure at the job level, and their square terms, as well as job level indicators. $Z_{i,t-1}$ denotes a vector of individual characteristics in the previous year including tenure at the company and its square term, and ε_{it} denotes a stochastic term. Note that the key focus of regression (1) is on the coefficients of $promotion_{it}$ and $rating_{it}$. From Table 1 we know that the tournament model predicts $\alpha_1 > 0$ and $\alpha_3 = 0$, while both the job assignment model and the signaling model predict $\alpha_1 > 0$ and $\alpha_3 > 0$.[72, 73]

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[72] Instead of treating performance rating as a continuous variable, I also run all the tests employing indicator variables of performance ratings. Overall, results on the coefficients of these indicator variables in each test are consistent with the coefficients on the continuous variable.

[73] Note that the current signaling theory predicts that there is no relationship between wage and promotion controlling for outputs because wage is fully determined by a worker's expected output. However, because performance rating is a coarse measure of output, promotion captures part of the positive relationship between output and wage in the data. Therefore, the signaling model predicts that promotion is positively correlated with wage given performance ratings when the ratings are coarse. To theoretically generate such a positive relationship between wage and promotion controlling for outputs without coarse performance ratings, one can introduce a slot constraint concerning promotions in the signaling model, which occurs with a strictly positive probability. The idea here is that when the slot constraint is binding, a worker might not get promoted even with a sufficiently high expected output. That is, two workers with the same expected output can have different job assignments and the one that is assigned to the high level job earns a higher wage. Therefore, with a slot constraint, the signaling model would predict that, controlling for even non-coarse performance ratings, promoted workers earn higher wages than non-promoted workers.

Table 5 displays the OLS estimates and the estimates controlling for individual fixed effects for the relationship between promotion and wage levels in the full sample. To begin with, columns (1) and (4) report the estimates for the regressions without controlling for performance ratings. In order to test the relationship between promotions and wages given performance ratings, I construct a more stringent sample where the observations contain no missing information on performance ratings. I report in columns (3) and (6) the estimates for the regressions where performance ratings are also controlled for using this more stringent sample. To exclude the possibility that changes in the coefficients of the regressions controlling and not controlling for performance ratings are caused by the changes in the underlying sample, I also run the regression of promotion and wages without controlling for performance ratings in the more stringent sample and report these results in columns (2) and (5) of Table 5. Overall, I find that promotions are positively related to wages. Moreover, performance ratings are positively related to wages controlling for promotions.

To examine those results more closely, consider first the OLS estimates in columns (1) to (3). Column (1) suggests that, all else equal, compensation among the promoted workers is on average 0.047 log points higher than that among the non-promoted workers. Further, column (3) shows that, when performance ratings are added as an explanatory variable, both promotion and performance ratings are positively related to wages. Specifically, all else equal, the average pay of the promoted workers is higher than that of the non-promoted workers by approximately 0.044 log points. Also, given promotions, a one unit improvement in performance rating increases compensation by approximately 0.8%. Lastly, all the coefficients mentioned above are significant at the 1% level.

I now discuss the rest of the findings from the wage-promotion regressions. To begin, age, education, tenure at the company, and tenure at the job level decreases wage growth at a decreasing rate, ceteris paribus.[74] Also, compensation increases in the starting level of compensation. Overall, the previous results are more consistent with the job assignment model and the signaling model because both of these models capture the positive relationship between performance ratings and wages given promotions.

Now consider the linear fixed-effect estimates shown in columns (4) to (6) of Table 5. On the whole, the results are consistent with the non-FE estimates. Specifically, column (4) tells us that, controlling for individual fixed effects, promotion increases the average level of compensation by approximately 0.037 log points, which supports both theories. Moreover, column (6) says that, controlling for performance ratings, workers earn an average promotion premium of 0.035 log points, while given promotions, a one unit improvement in performance ratings increases compensation by approximately 0.5%. As a final note, all the coefficients discussed above are significant at the 1% level.

5.1.2. The relationship between performance ratings and the probability of promotion (Test 2)

I use the following regression specification to study the relationship between performance ratings and the probability of promotion.

$$P(promotion_{it} = 1) = \Lambda(\beta_0 + \beta_1 rating_{i,t-1} + X_{it}\beta_2 + Z_{i,t-1}\beta_3) \qquad (2)$$

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[74] Note that because of the quadratic terms of age, education, and tenure included, the average levels of age, education, tenure at the company, and tenure at the job level at which they have zero impact on wage levels, are 54.57, 16.42, 4.42, and 9.28 for the OLS estimates, respectively. As a result, about 95.65%, 73.00%, 100%, and 100% of the observations in the stringent sample are located to the left of the critical points of the age, education, and tenure distributions, respectively. Therefore, the impact of age, education, and tenure on wage levels is mostly negative.

In the above regression, X_{it} and $Z_{i,t-1}$ are vectors of individual characteristics and Λ denotes the logit cumulative distribution function. According to Table 1, we know all three theories predict that $\beta_1 < 0$.

I report the logit marginal effects estimates for the relationship between promotion and performance ratings in Table 6. Consistent with the predictions of all three theories, I find performance ratings are significantly positively related to the probability of promotion.[75] To be specific, a one unit improvement in performance ratings increases the promotion probability by approximately 6.5 percentage points, which is significant at the 1% level. In addition, I find that the probability of promotion is negatively related to age and tenure at the company while positively related to tenure at the job level.[76] Moreover, education has no significant impact on promotion.[77] In summary, the positive relationship between performance ratings and the probability of promotion provides evidence consistent with all three theories.[78]

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[75] To be more precise, the tournament theory model I developed predicts a positive correlation between promotions and performance ratings across firms but not within each firm. However, if we allow each firm to run multiple tournaments, the above prediction also holds within a single firm. In addition, job-assignment theory predicts that promotion follows a step function of performance ratings. There is a similar issue and similar resolution concerning the signaling model.

[76] Because the regression controls for quadratic terms of age, education, and tenure, the levels of age, tenure at the company, and tenure at the job level at which they have zero impact on the probability of promotion, are 66.03, 13.95, and 7.53 years. Therefore, all of the observations in the sample are located to the left of the critical points of the age and tenure distribution. Therefore, age and tenure at the company decrease the probability of promotion, while tenure at the job level increases this probability.

[77] Note that my findings on tenure at the company are somewhat different from those of DeVaro and Waldman (2012) which is likely due to the different regression specifications we use. Specifically, aside from tenure at the company, DeVaro and Waldman also control for job title indicators as well as tenure at job titles.

[78] I also run linear FE estimates for the impact of performance ratings on promotion probabilities. Overall, the rating coefficients are quite similar to those under the non-FE specifications.

5.1.3. The relationship between promotion and turnover (Test 3)

Let $turnover_{it}$ denote an indicator variable whose value is 1 if worker i switches employers by the end of year t, and let $wage_{it} \equiv (lnW_{it},\ lnW_{it} - lnW_{i,t-1})$ denote a vector of wage measures. I consider the following regression specification for the investigation of the relationship between promotion and turnover.

$$P(turnover_{it} = 1) = \Lambda(\gamma_0 + \gamma_1 promotion_{i,t-1} + wage_{it}\gamma_2 + \gamma_3 rating_{i,t-1} + X_{it}\gamma_4 + Z_{i,t-1}\gamma_5) \quad (3)$$

In equation (3), Λ denotes the logit cumulative distribution function, X_{it} is a vector of individual characteristics in year t including age, education and their square terms and $Z_{i,t-1}$ is a vector of individual characteristics in year $t-1$ including tenure at the company, tenure at the job level and the associated square terms, as well as job level indicators. Recall from Table 1 that the tournament model predicts $\gamma_1 < 0$, the job assignment model predicts $\gamma_1 = 0$ and $\gamma_2 = \vec{0}$, while the signaling model predicts $\gamma_1 > 0$ and $\gamma_2 < \vec{0}$. In addition, the extension of the tournament model with firm specific human capital predicts that $\gamma_1 < 0$ and $\gamma_2 < \vec{0}$ while that of the enriched job assignment model predicts that $\gamma_1 > 0$ and $\gamma_2 < \vec{0}$.

Table 7 presents the OLS estimates and the average logit marginal effects estimates for the impact of promotion on turnover in the full sample. To test the robustness of the results to different wage measures, I adopt both log compensation and change in log compensation as two separate wage measures. Overall, I find evidence of an insignificant relationship between promotion and turnover, which is consistent with the job assignment model without human capital. Also, this relationship is robust to all regression specifications.

Because of the similarities between the OLS and the logit marginal effects estimates, I focus on the latter for a more detailed discussion. First, columns (5)-(8) show that promotion has no significant impact on turnover. On average, the size of the promotion coefficient is close to zero and insignificant, which is robust to all the regression specifications.

Aside from the promotion and turnover dynamics, I find that both log compensation and change in log compensation are significantly negatively related to separation probabilities, which is more consistent with the signaling model and the job assignment model with firm specific human capital. Specifically, column (6) shows that, controlling for promotions, a one percent increase in the level of compensation decreases turnover rates by approximately 4.9 percentage points, which is significant at the 1% level. Meanwhile, column (7) says that a one percent increase in compensation growth rate decreases the separation probability by about 25.7 percentage points, which is also significant at the 1% level. Lastly, column (8) suggests that, when both the level and the growth rate of compensation are controlled for, the latter has a more statistically significant impact on turnover. Specifically, a one percent increase in the compensation growth rate decreases turnover by approximately 23.1 percentage points, which is significant at the 1% level, while a one percent increase in the level of compensation decreases turnover by about 3.0 percentage points, which is significant at the 5% level.[79]

Overall, results from the full sample regressions suggest that each theory captures a subset of the empirical findings. Specifically, all three theories are able to explain the positive relationship between wages and promotions as well as that between performance ratings and the probability of promotion. However, tournament theory does not explain the positive relationship between

[79] I show the estimates of logit coefficients in Table 13 of Appendix 4. Overall, the logit coefficients are consistent with the logit marginal effect estimates in terms of both signs and significance levels.

performance ratings and wages after controlling for promotions. And it is not consistent with the insignificant relationship between promotion and turnover. The job assignment model, on the other hand, does a better job at explaining the empirical findings regarding the relationship between wage and performance rating controlling for promotions as well as the promotion and turnover dynamics. However, it is not consistent with the negative wage-turnover dynamics controlling for promotions. In addition, the signaling model is able to capture the positive relationships between promotions, performance ratings, and wages. However, it does not explain the insignificant promotion and turnover dynamics.[80] Lastly, the extensions of the tournament and the job assignment models with the human capital are able to capture the negative wage and turnover dynamics controlling for promotions. However, the negative promotion and turnover dynamics the tournament model predicts as well as the positive dynamics the job assignment model predicts contradict the empirical evidence of an insignificant relationship between promotion and turnover.

5.2. Results from the Level Subsamples

I now divide the full sample into subsamples by job level. My goal here is to test the conjecture that the tournament model is more applicable to higher level jobs while the signaling

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[80] According to Proposition 1.3, when firm specific human capital is small and return to effort does not vary much across jobs, signaling theory predicts a positive relationship between promotion and turnover. According to Baker, Gibbs, and Holmstrom (1994a), firm specific human capital is not prevalent in the BGH dataset. Also, because there are eight job levels in the BGH dataset, return to ability should not vary much across adjacent job levels. As a result, I interpret signaling theory as predicting a positive relationship between promotion and turnover in the BGH data. In other words, signaling theory does not explain the insignificant promotion-turnover pattern actually found in the full sample.

model is more applicable to lower level jobs due to both the incentive argument of Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach of Waldman (2013).[81]

My approach with breaking up the sample by job level is the following. I group the jobs of levels 1 and 2 into a low level subsample and I group the jobs of levels 3 to 7 into a high level subsample. Due to the sample size concern, this particular way of grouping the job levels allows me to split the full sample relatively evenly by the job level a worker is promoted from.[82] My conjecture is that, tournament theory should capture the promotion-turnover dynamics better in higher level jobs and signaling theory should capture these dynamics better in lower level jobs. Below I present the empirical findings from the subsamples. As a final note, I compile all of the subsample results for each test into one table for ease of comparison.

5.2.1. The relationship between promotions and wage levels (Test 1)

Table 8 displays the OLS estimates for the relationship between promotions and wage levels, where columns (1) and (2) report the results without controlling for performance ratings while columns (5) and (6) report the results controlling for performance ratings. Similar to the full sample results, as a robustness check, in columns (3) and (4) I also report the results without controlling for performance ratings using the more stringent sample, which contains no missing information on performance ratings. Overall, similar to the findings from the full sample, the subsample findings are more consistent with the predictions of job assignment theory and

[81] Note that the incentive argument is silent on which role of promotion prevails at lower level jobs while the hybrid approach argues that the signaling role of promotion should prevail.

[82] I also experimented with other ways of splitting the job levels. The promotion coefficients in the promotion-turnover regressions are more negative in terms of magnitudes as the high-level sample becomes more exclusive of higher level jobs. This finding not only serves as a robustness check of my approach, but also provides further evidence along the lines of my results reported below consistent with the conjecture that tournament theory is more applicable to jobs at higher hierarchical levels.

signaling theory. Specifically, in both of the level subsamples, I find that promotions are significantly positively related to wage levels with and without the control of performance ratings, while performance ratings are positively related to wages controlling for promotions.

Because of the similarities between the two sets of results, I focus on the ones that control for performance ratings in the following discussion. Column (5) of Table 8 shows that, in the high level subsample, given performance ratings, compensation among the promoted workers is 0.051 log points higher than that among the non-promoted workers. Moreover, holding fixed the promotion outcomes, a one unit increase in performance rating increases the level of compensation by approximately 1.2%, ceteris paribus. On the other hand, findings from the low level subsample displayed in column (4) of Table 8 suggest that the wage premium associated with promotions is 17.7% lower, while the rating premium is 75% lower in the low level subsample than in the high level subsample. Further, all coefficients discussed above are significant at the 1% level.[83] Finally, the promotion premiums are not statistically significantly different between the level subsamples, while the rating premiums are.

Table 9 shows the associated linear fixed-effect estimates of the promotion and wage dynamics of the subsamples. Overall, all of the results including the individual fixed effects are quite consistent with the non-FE estimates. Specifically, as shown in columns (5) and (6), when controlling for performance ratings, promotion increases the wage premium in the high level subsample by about 3.7 percentage points, and that in the low level subsample by about 3.1 percentage points. Moreover, given promotions, a one unit improvement in performance rating increases the wage premium in the high level subsample by about 0.9 percentage points. Lastly,

[83] One exception is the rating coefficient in the low level subsample is significant at the 5% level.

all of the coefficients mentioned above are significant at the 1% level. Finally, similar to the findings of the non-FE estimates, the promotion coefficients are not statistically significantly different between the level subsamples in all regressions.

In summary, similar to my conclusions in the full sample section, the subsample findings regarding wage and promotion dynamics are consistent with the predictions of all three theories.[84] Moreover, the job assignment model and the signaling model explain the results from both subsamples better in the sense that they capture the positive relationship between performance ratings and wages.

5.2.2. The relationship between performance ratings and the probability of promotion (Test 2)

Table 10 shows the average logit marginal effects estimates for the effects of performance ratings on the probability of promotion in the level subsamples. Consistent with the full sample results, I find that in both subsamples performance ratings are significantly positively related to the probability of promotion, which supports all three theories. Specifically, column (1) of Table 10 says that, in the high level sample, a one unit improvement in performance ratings increases the probability of promotion by approximately 5.2 percentage points. Similarly, column (2) shows that, in the low level subsample, workers with a one unit improvement in performance ratings are 8.3 percentage points more likely to be promoted. In addition, both of these coefficients are significant at the 1% level.

Also, I find that the size of the rating effects in the lower level jobs is approximately 1.6 times of that in the higher level jobs, and this difference is statistically significant between the level

[84] However, tournament theory does not describe the data in the high level subsample perfectly because it does not explain the positive relationship between performance ratings and wages controlling for promotions.

subsamples. One potential explanation for this pattern is that promotion gets progressively less likely as job level increases. In other words, because chances of promotion decrease with job level, a one unit increase of performance ratings in higher level jobs might appear to have a much smaller effect on the promotion probability in terms of absolute values, even though the size of the impact might stay relatively the same in terms of percentage changes. Another possible explanation for this pattern is that performance ratings tend to vary less in higher hierarchical levels and thus might not be able to capture as much variation of the promotion probabilities. In fact, one can find evidence consistent with both of the aforementioned conjectures in Table 3. That is, both the mean promotion rate and the standard error of performance ratings decrease with job level.[85]

In summary, consistent with the findings from the full sample, I find that performance ratings are significantly positively related to the probability of promotion in both of the level subsamples, which supports the predictions of all three theories.[86]

5.2.3. The relationship between promotion and turnover (Test 3)

In this subsection, I present the key findings in the subsample section, i.e., the relationship between promotion and turnover. Similar to my approach with the full sample, I run both linear and logit regressions and control for two different wage measures as a robustness check of my

[85] Note that the standard error of performance ratings at job level 6 is slightly higher than that at job level 5.

[86] In both of the level subsamples, tenure is mostly positively related to the probability of promotion, which is consistent with the full sample results. However, age is positively related to the probability of promotion in the high level subsample, while negatively related to this probability in the low level subsample. The reason why age has a different impact on the probability of promotion at different job levels remains unclear.

results. For completeness, I report the associated full sample results with promotion-level and wage-level interactions in Table 14 of Appendix 4.

Tables 11 and 12 contain the OLS and logit marginal effects estimates for the promotion and turnover dynamics of the level subsamples, where columns (1) through (4) in both tables are for the regression specifications with different wage measures. On the whole, there is strong evidence that promotion is significantly negatively related to turnover in the high level subsample, while it is positively related to turnover in the low level subsample.[87] In addition, wage is negatively related to turnover controlling for promotions. These findings suggest that tournament theory with human capital better explains the promotion and turnover dynamics at higher job levels, while both the signaling theory and the job assignment theory with firm specific human capital better capture the dynamics at lower job levels.

Because of the similarities between the OLS and the logit marginal effects estimates, I focus on the latter for more detail. Table 12 demonstrates that, given workers are from the higher level jobs, those who are promoted are approximately 3.0 percentage points less likely to leave than those who are not, which is significant at the 10% level. On the other hand, in the low level subsample, promotion on average increases turnover by about 1.2 percentage points, which is significant at the 10% level when controlling for the level of compensation. Moreover, the differences in the promotion coefficients between level subsamples are statistically significant across all regression specifications, which suggests the promotion schemes at different hierarchical levels are substantially different.

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[87] Note that the positive relationship between promotion and turnover in the low level subsample is only significant when the level of compensation is controlled for.

As for the coefficients of the level and growth rate of compensation, I find that only the growth rate has a significant impact on turnover in the high level subsample, while both of them significantly decrease turnover in the low level subsample. Specifically, all else equal, a one percent increase in the compensation growth rate significantly decreases the separation probability in the higher level jobs by approximately 31.3 percentage points. On the other hand, among lower level jobs, a one log point increase in the level of compensation reduces the turnover probability by approximately 6.5 percentage points, while a one percent increase in the compensation growth rate reduces the turnover probabilities by approximately 19.1 percentage points. Furthermore, all of the compensation coefficients mentioned above are significant at the 5% level. Note, however, comparing the coefficients of the compensation measures, we can see that the differences in the coefficients of both level and change of compensation between the level subsamples are insignificant.[88] Overall, it seems that the tournament model with human capital better explains the promotion-turnover dynamics at higher job levels, while the signaling model and the job assignment model with human capital better explain the dynamics at lower job levels. However, according to Baker, Gibbs, and Holmstrom (1994a), firm specific human capital is not significant at the firm in this study. Therefore, it seems more plausible to interpret the finding of the positive promotion and turnover dynamics at lower job levels of the hierarchy as evidence consistent with the signaling theory. Overall, the subsample results on the promotion and turnover relationship shows evidence consistent with the conjectures of both the incentive

[88] For completeness, I report the estimates for logit coefficients in Table 15 in Appendix 4. Overall, the coefficients are consistent with the marginal effects in terms of both sign and significance level.

argument of Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach proposed by Waldman (2013).[89, 90]

Before we move on, it is worth pointing out an alternative interpretation of the insignificant relationship between promotion and turnover in the full sample. Recall from the theories that the tournament model predicts that promotion is negatively related to turnover, while the signaling model predicts that promotion is positively related to turnover. Therefore, if the reality were a mixture of the two theories, as the subsample results suggest, one might predict that promotion would have no significant impact on turnover in the full sample. That is to say, instead of arguing that the overall evidence favors job assignment theory without human capital, it seems more appropriate to view the full sample findings as further evidence consistent with the subsample findings, i.e., the incentive role and the signaling role of promotions coexist in the BGH data.

I now briefly summarize the main empirical findings from the level subsamples. First, promotion is significantly negatively related to turnover in the higher level jobs, while it is significantly positively related to turnover in the lower level jobs. Moreover, controlling for promotions, changes in compensation are significantly negatively associated with the separation probability in both subsamples, while compensation is only significantly negatively related to

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[89] Note that my initial extension of tournament theory does not explain the negative wage and turnover relationship given promotions. See Chapter 2 for an extension of the tournament model which captures such negative wage and turnover dynamics.

[90] To see whether the differences in the promotion coefficients across the level subsamples are caused by the differences in the distribution of individual characteristics across those subsamples, I re-estimated the promotion coefficients of both subsamples by evaluating the rest of the explanatory variables at the quantiles of their full sample distributions. I report the findings in Table 16 of Appendix 4. Overall, the results are consistent with the subsample findings, which is further evidence consistent with my conclusion that tournament theory is more applicable to the promotion-turnover dynamics in higher level jobs while signaling theory is more applicable to the dynamics in lower level jobs.

turnover in the low level subsample. Overall, results on the promotion and turnover dynamics provide evidence consistent with the conjecture that tournament theory is more applicable to higher job levels while signaling theory is more applicable to lower job levels.[91] Two of the potential explanations for these empirical findings include an incentive argument based on Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach of Waldman (2013).

6. Conclusion

Current theory assigns three different roles to promotions, namely, rewarding previous performance, allocating workers to tasks, and signaling ability to outside firms. In the first chapter of my dissertation titled "Theory on Promotion and Turnover", I extend tournament theory, job assignment theory, and signaling theory with turnover and compare the three roles of promotion via the theories' implications for promotion and turnover dynamics. In the second chapter of my dissertation titled "Theoretical Extensions on Promotion and Turnover", I further extend both tournament and job assignment theories with firm specific human capital and generate predictions regarding wage and turnover dynamics controlling for promotions. In this chapter, I first empirically test these predictions using a large dataset from a single firm in the financial services industry in the U.S. and show that each theory is able to capture some of the empirical findings.

To investigate whether tournament theory is more applicable to jobs in which incentives are more likely to be important and market wages are less likely to be binding, I divide the sample further by hierarchical level. One of the main findings of this chapter is that the tournament

[91] As a robustness check, I also ran all three tests on the observations where bonus data are not missing using total compensation as the wage measure, where total compensation is defined as the summation of salary and bonus. Results are mostly consistent with those using salary as the wage measure.

model with firm specific human capital better explains the promotion and turnover dynamics in higher level jobs, while the signaling model better explains the dynamics in lower level jobs. Overall, the empirical findings suggest that the role of rewarding past performance of promotion prevails at higher job levels while the signaling role of promotion prevails at lower job levels. These findings are consistent with both an incentive argument based on Rosen (1982) and Baker, Jensen, and Murphy (1988) and the hybrid approach of Waldman (2013).

I now propose two potential ways to extend the current study. Following the idea of Waldman (2013), the first way to is to build a formal hybrid model that combines the classic tournament approach of Lazear and Rosen (1981) and the market based tournament approach represented by Zabonjik and Bernhardt (2001) and Ghosh and Waldman (2010). Specifically, instead of a single promotion, the hybrid model would generate a sequence of promotions, where the predictions of the model would be as if promotions at earlier rounds act more like a signaling device, while those at later rounds act more like an incentive device. My conjecture is that such a hybrid model would be able to formally capture the subsample results that the tournament role and the signaling role of promotions seem to coexist in reality.

The second way to extend the current study is to explore promotion and turnover dynamics using other datasets, such as matched employer-employee datasets that contain multiple firms, industries, and occupations. Besides providing a robustness check of the empirical findings in this paper, such an empirical extension might be able to shed light on how promotion and turnover dynamics differ across industries and occupations, which would provide an even broader understanding of how internal labor markets operate.

Table 1. Summary of Predicted Correlations

Theory		Tournament		Job Assignment		Signaling
Firm Specific Human Capital		N	Y	N	Y	---
Promotion and Wage	Controlling for Ratings	+	+	+①	+①	+①
	Without Controlling for Ratings	+	+	+	+	+
Ratings and Wage Controlling for Promotions		0	NP	+	+	+
Ratings and Probability of Promotion		+	+	+	+	+
Promotion and Turnover	Controlling for Wages	NP	NP	0	+	NP
	Without Controlling for Wages	−	−②	0	0	+③
Wage and Turnover Controlling for Promotions		NP	−	0	−	−

Note: ① Holds when performance ratings are coarse; ② Holds when firm specific human capital is sufficiently small; ③ Holds when return to ability are sufficiently close at different job levels and firm specific human capital is sufficiently small; "+" stands for positive relationship, "−" stands for negative relationship, "0" stands for no relationship, and "NP" stands for no prediction.

Table 2. Descriptive Statistics, Full Sample

Variable	Mean [Standard Deviations]
Annual salary (measured in 1988 dollars)	55310.13
	[22651.86]
Log-salary(t)-Log-salary(t-1)	0.05
	[0.07]
Worker's age (in years)	38.71
	[7.87]
Education (in years)	15.59
	[2.48]
Tenure at current firm (in years)	6.04
	[3.73]
Job level	2.65
	[1.09]
Tenure at current job level (in years)	3.33
	[2.43]
Tenure at pre-promotion job level (in years)	3.83
	[2.27]
Promotion to higher hierarchical level	0.20
	[0.4]
Turnover rate	0.09
	[0.29]
Performance rating (1=best; 5=worst)	1.89
	[0.71]
Rating=1	30.56%
Rating=2	50.69%
Rating=3	17.92%
Rating=4	0.78%
Rating=5	0.04%
Number of workers	4216
Number of observations	22060
Sample size of performance rating	15949

Table 3. Summary Statistics of Key Variables by Job Level, Full Sample

Standard deviations in brackets.

Job level	Salary	Δ Log-salary	Proportion of workers promoted	Turnover Rate	Performance Rating	Sample size	Sample size (%)
1	38920.44	0.02	0.36	0.08	2.16	3667	16.62%
	[8108.58]	[0.06]	[0.48]	[0.28]	[0.74]		
2	43877.24	0.04	0.25	0.10	2.02	6428	29.14%
	[8357.87]	[0.06]	[0.43]	[0.29]	[0.7]		
3	53086.39	0.05	0.15	0.10	1.83	6390	28.97%
	[9870.61]	[0.06]	[0.36]	[0.29]	[0.67]		
4	77489.84	0.06	0.02	0.10	1.60	5118	23.20%
	[20415.15]	[0.07]	[0.14]	[0.3]	[0.64]		
5	119835.81	0.06	0.06	0.09	1.53	341	1.55%
	[34679.11]	[0.09]	[0.23]	[0.28]	[0.56]		
6	158207.46	0.05	0.00	0.06	1.64	114	0.52%
	[52446.59]	[0.1]	[0.00]	[0.24]	[0.89]		
7	331257.88	0.01	0.00	0.00	---	2	0.01%
	[10300.82]	[0.04]	[0.00]	[0.00]	---		

Δ log-salary is defined as the change in log-salary between the contemporaneous year and the previous year; both salary and Δ log-salary are measured in 1988 dollars; sample sizes of performance rating by level are 2822, 4725, 4644, 3561, 153, 44, and 0, while those for proportion of workers promoted are 3159, 5412, 5225, 4022, 277, 77, and 2 for job levels 1 through 7, respectively.

Table 4. Descriptive Statistics, Level Subsamples

Standard deviations in brackets.

Variable	Low level	High level
Annual salary (measured in 1988 dollars)	44781.42	71128.13
	[9844.14]	[25993.99]
Log-salary(t)-Log-salary(t-1)	0.04	0.05
	[0.06]	[0.07]
Worker’s age (in years)	38.21	41.43
	[7.73]	[7.16]
Education (in years)	15.01	16.20
	[2.31]	[2.52]
Tenure at current firm (in years)	5.47	8.62
	[2.67]	[3.72]
Job level	2.08	3.68
	[0.71]	[0.62]
Tenure at current job level (in years)	3.10	4.38
	[2.36]	[2.57]
Tenure at pre-promotion job level (in years)	3.81	4.75
	[2.17]	[2.38]
Promotion to higher hierarchical level	0.26	0.10
	[0.44]	[0.3]
Turnover rate	0.08	0.09
	[0.27]	[0.29]
Performance rating (1=best; 5=worst)	2.02	1.77
	[0.72]	[0.69]
Rating=1	23.31%	37.55%
Rating=2	52.48%	48.97%
Rating=3	23.09%	12.86%
Rating=4	1.07%	0.63%
Rating=5	0.05%	0.00%
Number of workers	2679	1861
Number of observations	9775	8280
Sample size of performance rating	7302	5894

The low level subsample contains observations at levels 1 and 2 while the high level subsample contains observations at levels 3 through 7.

Table 5. OLS and Linear Fixed Effects Estimates for the Impact of Promotion on Log-salary, Full Sample

Dependent variable	Log-salary(t)					
	OLS			Linear Fixed Effects		
	Full Sample	Stringent Sample		Full Sample	Stringent Sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Promotion(t)	0.047***	0.045***	0.044***	0.037***	0.036***	0.035***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Rating(t-1)	---	---	-0.008***	---	---	-0.005***
	---	---	(0.001)	---	---	(0.001)
Log-salary(t-1)	0.973***	0.967***	0.962***	0.866***	0.890***	0.885***
	(0.003)	(0.004)	(0.004)	(0.007)	(0.009)	(0.009)
Age(t)*100	-0.963***	-0.921***	-0.885***	---	---	---
	(0.069)	(0.083)	(0.082)	---	---	---
$Age(t)^2$ *10000	0.890***	0.837***	0.810***	-0.750***	-0.386	-0.396*
	(0.083)	(0.099)	(0.098)	(0.205)	(0.235)	(0.234)
Education(t)*100	-0.661***	-0.526**	-0.499**	-2.026**	-2.492*	-2.453*
	(0.195)	(0.235)	(0.235)	(0.857)	(1.308)	(1.320)
$Education(t)^2$*10000	2.010***	1.585**	1.538**	5.892**	8.000**	7.864*
	(0.605)	(0.735)	(0.737)	(2.579)	(4.031)	(4.063)
Tenure at company(t-1)*100	0.048	-0.380***	-0.359***	0.279	-0.398	-0.360
	(0.063)	(0.077)	(0.076)	(0.210)	(0.244)	(0.242)
Tenure at $company(t-1)^2$*10000	1.419***	3.600***	3.438***	3.900***	5.823***	5.708***
	(0.346)	(0.402)	(0.392)	(0.459)	(0.545)	(0.540)
Tenure at level(t)*100	-0.809***	-0.511***	-0.375***	-0.006	0.032	0.098
	(0.091)	(0.104)	(0.103)	(0.117)	(0.141)	(0.141)
Tenure at $level(t)^2$*10000	4.395***	2.678***	2.064***	0.422	-0.042	-0.336
	(0.663)	(0.726)	(0.702)	(0.831)	(0.958)	(0.944)
Average log-salary	10.857	10.858	10.858	10.857	10.858	10.858
	(0.340)	(0.323)	(0.323)	(0.340)	(0.323)	(0.323)
Level(t) indicators	Yes	Yes	Yes	Yes	Yes	Yes
N	22060	14759	14759	22060	14759	14759
Adj. R-sq.	0.970	0.968	0.968	0.977	0.976	0.976

Standard errors in parentheses, clustered by individual; individual fixed effects are calculated; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; job levels indicate pre-promotion job levels; observations in the stringent sample are those that contain no missing information on performance ratings.

Table 6. Logit Marginal Effects for Performance Ratings and the Probability of Promotion, Full Sample

Dependent variable	Promotion(t)
Rating(t-1)	-0.065***
	(0.005)
Age(t)*100	-2.620***
	(0.394)
$Age(t)^2$*10000	1.984***
	(0.498)
Education(t)*100	0.265
	(1.166)
$Education(t)^2$*10000	4.379
	(3.599)
Tenure at company(t-1)*100	-1.794***
	(0.499)
Tenure at company$(t-1)^2$*10000	6.430**
	(3.137)
Tenure at level(t)*100	12.446***
	(0.956)
Tenure at $level(t)^2$*10000	-82.594***
	(8.881)
Average promotion rate	0.195
	(0.396)
Level(t) indicators	Yes
N	14915
Pseudo R-sq.	0.189
Log likelihood	-5973.684

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; average marginal effects are calculated; job levels indicate pre-promotion job levels.

Table 7. OLS and Logit Marginal Effects Estimates for the Impact of Promotion on Labor Turnover, Full Sample

Dependent variable	Turnover(t)							
	OLS				Logit Marginal Effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Promotion(t-1)	0.002	0.008	0.006	0.009	0.002	0.007	0.005	0.008
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)
Log-salary(t)	---	-0.053***	---	-0.033**	---	-0.049***	---	-0.030**
	---	(0.014)	---	(0.015)	---	(0.013)	---	(0.014)
Log-salary(t)-Log-salary(t-1)	---	---	-0.258***	-0.230***	---	---	-0.257***	-0.231***
	---	---	(0.044)	(0.045)	---	---	(0.046)	(0.048)
Age(t)*100	-0.707**	-0.593*	-0.977***	-0.877***	-0.491	-0.370	-0.755**	-0.653*
	(0.328)	(0.331)	(0.329)	(0.332)	(0.331)	(0.334)	(0.333)	(0.338)
Age(t)^2*10000	0.555	0.417	0.804**	0.691*	0.278	0.134	0.519	0.405
	(0.377)	(0.380)	(0.378)	(0.382)	(0.397)	(0.401)	(0.398)	(0.403)
Education(t)*100	2.251**	2.222**	2.141**	2.135**	3.082***	3.140***	2.963***	3.008***
	(0.906)	(0.910)	(0.910)	(0.911)	(0.867)	(0.874)	(0.869)	(0.872)
Education(t)^2*10000	-4.959*	-4.675	-4.600	-4.461	-7.321***	-7.294***	-6.939***	-6.955***
	(2.864)	(2.882)	(2.875)	(2.885)	(2.572)	(2.585)	(2.573)	(2.581)
Tenure at company(t-1)*100	-1.390***	-1.659***	-1.402***	-1.569***	-1.411***	-1.643***	-1.421***	-1.561***
	(0.336)	(0.343)	(0.336)	(0.342)	(0.356)	(0.356)	(0.351)	(0.353)
Tenure at company(t-1)^2*10000	5.247***	6.421***	5.824***	6.498***	5.137***	6.179***	5.796***	6.365***
	(1.738)	(1.760)	(1.746)	(1.761)	(1.964)	(1.959)	(1.944)	(1.943)
Tenure at level(t-1)*100	1.087**	1.332***	0.902*	1.076**	1.216**	1.416**	0.991*	1.132**
	(0.470)	(0.472)	(0.471)	(0.473)	(0.557)	(0.554)	(0.545)	(0.545)
Tenure at level(t-1)^2*10000	-5.447	-6.493*	-4.440	-5.204	-5.963	-6.694	-4.740	-5.276
	(3.565)	(3.544)	(3.574)	(3.559)	(4.466)	(4.431)	(4.358)	(4.339)
Rating(t-1)	0.023***	0.020***	0.021***	0.019***	0.023***	0.019***	0.021***	0.019***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Average turnover rate	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
	(0.273)	(0.273)	(0.273)	(0.273)	(0.273)	(0.273)	(0.273)	(0.273)
Level(t-1) indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	12751	12751	12751	12751	12751	12751	12751	12751
Adj. R-sq./ pseudo R-sq.	0.015	0.016	0.018	0.018	0.030	0.032	0.035	0.036
Log likelihood	---	---	---	---	-3477.833	-3470.437	-3458.288	-3455.771

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; average marginal effects are calculated.

Table 8. OLS Estimates for the Impact of Promotion on Log-salary, Level Subsamples

Dependent variable	Log-salary(t)					
	Full Sample		Stringent Sample		Stringent Sample	
	High level	Low level	High level	Low level	High level	Low level
	(1)	(2)	(3)	(4)	(5)	(6)
Promotion(t)	0.053***	0.045***	0.053***	0.042***	0.051***	0.042***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Rating(t-1)	---	---	---	---	-0.012***	-0.003**
	---	---	---	---	(0.002)	(0.001)
Log-salary(t-1)	0.986***	0.965***	0.979***	0.963***	0.971***	0.961***
	(0.005)	(0.004)	(0.006)	(0.005)	(0.006)	(0.005)
Age(t)*100	-0.782***	-0.974***	-0.709***	-0.969***	-0.681***	-0.953***
	(0.144)	(0.092)	(0.167)	(0.107)	(0.165)	(0.108)
Age(t)^2*10000	0.621***	0.989***	0.514***	0.998***	0.504***	0.983***
	(0.164)	(0.109)	(0.193)	(0.126)	(0.190)	(0.127)
Education(t)*100	-0.654**	-0.556**	-0.691*	-0.151	-0.621*	-0.142
	(0.311)	(0.277)	(0.366)	(0.316)	(0.362)	(0.317)
Education(t)^2*10000	1.970**	1.653*	2.055*	0.305	1.914*	0.293
	(0.933)	(0.880)	(1.101)	(1.002)	(1.096)	(1.007)
Tenure at company(t-1)*100	0.296***	-0.680***	0.153	-0.975***	0.100	-0.963***
	(0.094)	(0.115)	(0.112)	(0.133)	(0.110)	(0.132)
Tenure at company(t-1)^2*10000	0.244	4.180***	1.146**	5.924***	1.362**	5.893***
	(0.487)	(0.699)	(0.566)	(0.799)	(0.547)	(0.790)
Tenure at level(t)*100	-0.667***	-0.578***	-0.393**	-0.293*	-0.255	-0.247
	(0.155)	(0.135)	(0.172)	(0.160)	(0.167)	(0.160)
Tenure at level(t)^2*10000	3.690***	3.792***	1.899	1.894*	1.364	1.659
	(1.123)	(0.951)	(1.166)	(1.084)	(1.104)	(1.077)
Average log-salary	11.119	10.687	11.124	10.705	11.124	10.705
	(0.313)	(0.212)	(0.290)	(0.207)	(0.290)	(0.207)
Level(t) indicators	Yes	Yes	Yes	Yes	Yes	Yes
N	8280	9775	5631	7091	5631	7091
Adj. R-sq.	0.961	0.935	0.957	0.933	0.957	0.933

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low level subsample contains promotions from job levels 1 and 2 while the high level subsample contains promotions from job levels 3 through 7; observations in the stringent sample contain no missing information on performance ratings.

Table 9. Linear Fixed Effects for Promotion and Log-salary, Level Subsamples

Dependent variable	Log-salary(t)					
	Full Sample		Stringent Sample		Stringent Sample	
	High level	Low level	High level	Low level	High level	Low level
	(1)	(2)	(3)	(4)	(5)	(6)
Promotion(t)	0.037***	0.036***	0.038***	0.031***	0.037***	0.031***
	(0.004)	(0.002)	(0.005)	(0.003)	(0.005)	(0.003)
Rating(t-1)	---	---	---	---	-0.009***	-0.000
	---	---	---	---	(0.002)	(0.002)
Log-salary(t-1)	0.804***	0.785***	0.808***	0.832***	0.801***	0.832***
	(0.015)	(0.015)	(0.020)	(0.020)	(0.020)	(0.020)
$Age(t)^2$*10000	-2.521***	-0.459	-1.922***	-0.053	-1.885***	-0.055
	(0.443)	(0.385)	(0.519)	(0.461)	(0.513)	(0.462)
Education(t)*100	-2.166	-0.352	-3.748	-1.763	-3.755	-1.758
	(1.568)	(1.330)	(2.986)	(1.950)	(2.972)	(1.952)
$Education(t)^2$*10000	6.720	0.379	11.958	4.981	11.941	4.963
	(4.647)	(3.943)	(9.227)	(5.580)	(9.165)	(5.585)
Tenure at company(t-1)*100	2.251***	-0.004	1.272**	-0.743*	1.240**	-0.739*
	(0.445)	(0.371)	(0.550)	(0.438)	(0.540)	(0.439)
Tenure at $company(t-1)^2$*10000	4.928***	2.973**	7.396***	5.715***	7.459***	5.711***
	(0.737)	(1.160)	(0.931)	(1.422)	(0.922)	(1.421)
Tenure at level(t)*100	-0.019	-0.021	0.068	-0.116	0.153	-0.110
	(0.213)	(0.201)	(0.281)	(0.249)	(0.276)	(0.250)
Tenure at $level(t)^2$*10000	-0.265	0.702	-1.517	0.770	-1.757	0.738
	(1.441)	(1.391)	(1.840)	(1.694)	(1.778)	(1.698)
Average log-salary	11.119	10.687	11.124	10.705	11.124	10.705
	(0.313)	(0.212)	(0.290)	(0.207)	(0.290)	(0.207)
Level(t) indicators	Yes	Yes	Yes	Yes	Yes	Yes
N	8280	9775	5631	7091	5631	7091
Adj. R-sq.	0.971	0.956	0.970	0.956	0.970	0.956

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; individual fixed effects are calculated; the low level subsample contains promotions from job levels 1 and 2 while the high level subsample contains promotions from job levels 3 through 7; observations in the stringent sample contain no missing information on performance ratings.

Table 10. Logit Marginal Effects for Performance Ratings and the Probability of Promotion, Level Subsamples

Dependent variable	Promotion(t)	
	High level	Low level
	(1)	(2)
Rating(t-1)	-0.052***	-0.083***
	(0.006)	(0.008)
Age(t)*100	-2.258***	-2.049***
	(0.560)	(0.651)
Age(t)^2*10000	1.960***	1.101
	(0.677)	(0.812)
Education(t)*100	2.257*	-5.210**
	(1.285)	(2.257)
Education(t)^2*10000	-3.978	21.907***
	(3.787)	(7.255)
Tenure at company(t-1)*100	-1.370***	-4.595***
	(0.479)	(0.947)
Tenure at company(t-1)^2*10000	5.382*	24.227***
	(2.791)	(6.299)
Tenure at level(t)*100	3.573***	12.916***
	(0.855)	(1.587)
Tenure at level(t)^2*10000	-16.308**	-89.744***
	(6.361)	(14.147)
Average promotion rate	0.095	0.253
	(0.293)	(0.435)
Level(t) indicators	Yes	Yes
N	5711	7149
Pseudo R-sq.	0.231	0.147
Log likelihood	-1383.300	-3447.826

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low level subsample contains promotions from job levels 1 and 2 while the high level subsample contains promotions from job levels 3 through 7; for all the regressions average marginal effects are calculated.

Table 11. OLS Estimates for the Impact of Promotion on Labor Turnover, Level Subsamples

Dependent variable	Turnover(t)							
	(1)		(2)		(3)		(4)	
	High level	Low level	High level	Low level	High level	Low level	High level	Low level
Promotion(t-1)	-0.027**	0.008	-0.024*	0.016**	-0.023**	0.012	-0.024*	0.017**
	(0.012)	(0.008)	(0.012)	(0.008)	(0.012)	(0.008)	(0.012)	(0.008)
Log-salary(t)	---	---	-0.023	-0.074***	---	---	0.005	-0.060***
	---	---	(0.023)	(0.018)	---	---	(0.023)	(0.019)
Log-salary(t)-Log-salary(t-1)	---	---	---	---	-0.297***	-0.219***	-0.301***	-0.172***
	---	---	---	---	(0.062)	(0.063)	(0.063)	(0.066)
Age(t)*100	0.907	-1.402***	0.936*	-1.229***	0.622	-1.672***	0.611	-1.474***
	(0.555)	(0.412)	(0.557)	(0.415)	(0.554)	(0.415)	(0.555)	(0.420)
Age(t)^2*10000	-1.283**	1.380***	-1.321**	1.178**	-1.047*	1.656***	-1.035*	1.432***
	(0.623)	(0.480)	(0.626)	(0.483)	(0.623)	(0.483)	(0.624)	(0.488)
Education(t)*100	2.283*	0.481	2.318*	0.160	2.116*	0.417	2.106*	0.170
	(1.241)	(1.594)	(1.243)	(1.600)	(1.245)	(1.596)	(1.244)	(1.601)
Education(t)^2*10000	-5.916	1.583	-5.941	2.895	-5.381	1.776	-5.368	2.801
	(3.689)	(5.275)	(3.696)	(5.302)	(3.701)	(5.281)	(3.698)	(5.306)
Tenure at company(t-1)*100	-1.480***	-0.959*	-1.587***	-1.232**	-1.421***	-1.088*	-1.397***	-1.282**
	(0.450)	(0.568)	(0.463)	(0.572)	(0.451)	(0.571)	(0.463)	(0.573)
Tenure at company(t-1)^2*10000	4.890**	2.784	5.350**	3.855	5.198**	3.814	5.101**	4.462
	(2.286)	(3.165)	(2.329)	(3.179)	(2.291)	(3.194)	(2.328)	(3.198)
Tenure at level(t-1)*100	2.015***	0.204	2.139***	0.391	1.857***	0.077	1.828***	0.256
	(0.595)	(0.745)	(0.606)	(0.744)	(0.593)	(0.747)	(0.602)	(0.748)
Tenure at level(t-1)^2*10000	-13.886***	3.679	-14.330***	2.699	-12.941***	4.335	-12.829***	3.396
	(4.227)	(5.742)	(4.245)	(5.714)	(4.226)	(5.768)	(4.230)	(5.744)
Rating(t-1)	0.030***	0.019***	0.028***	0.014***	0.027***	0.018***	0.027***	0.014***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Average turnover rate	0.085	0.078	0.085	0.078	0.085	0.078	0.085	0.078
	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)
Level(t-1) indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5644	7107	5644	7107	5644	7107	5644	7107
Adj. R-sq.	0.015	0.020	0.015	0.022	0.019	0.022	0.018	0.023

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low level subsample contains promotions from job levels 1 and 2 while the high level subsample contains promotions from job levels 3 through 7.

Table 12. Logit Marginal Effects for Promotion and Labor Turnover, Level Subsamples

Dependent variable	Turnover (t)							
	(1)		(2)		(3)		(4)	
	High level	Low level	High level	Low level	High level	Low level	High level	Low level
Promotion(t-1)	-0.032**	0.007	-0.029*	0.015*	-0.029*	0.011	-0.030*	0.016**
	(0.016)	(0.007)	(0.016)	(0.008)	(0.016)	(0.007)	(0.016)	(0.008)
Log-salary(t)	---	---	-0.021	-0.071***	---	---	0.006	-0.058***
	---	---	(0.021)	(0.019)	---	---	(0.021)	(0.019)
Log-salary(t)-Log-salary(t-1)	---	---	---	---	-0.310***	-0.214***	-0.315***	-0.168**
	---	---	---	---	(0.069)	(0.065)	(0.070)	(0.067)
Age(t)*100	1.015*	-1.017**	1.050*	-0.839**	0.776	-1.309***	0.761	-1.102**
	(0.605)	(0.423)	(0.609)	(0.425)	(0.609)	(0.427)	(0.611)	(0.434)
$Age(t)^2$*10000	-1.444**	0.901*	-1.488**	0.701	-1.261*	1.207**	-1.244*	0.978*
	(0.706)	(0.522)	(0.710)	(0.524)	(0.710)	(0.525)	(0.713)	(0.530)
Education(t)*100	2.721**	2.271*	2.795**	2.120*	2.595*	2.169*	2.570*	2.053*
	(1.330)	(1.190)	(1.338)	(1.193)	(1.335)	(1.189)	(1.336)	(1.191)
$Education(t)^2$*10000	-7.083*	-4.102	-7.218*	-3.342	-6.650*	-3.799	-6.599*	-3.201
	(3.830)	(3.625)	(3.845)	(3.623)	(3.833)	(3.620)	(3.833)	(3.616)
Tenure at company(t-1)*100	-1.354***	-1.016	-1.447***	-1.238*	-1.324***	-1.135	-1.296***	-1.284*
	(0.461)	(0.713)	(0.468)	(0.704)	(0.457)	(0.700)	(0.466)	(0.695)
Tenure at $company(t-1)^2$*10000	4.110	1.691	4.517*	2.521	4.701*	2.757	4.593*	3.180
	(2.561)	(4.604)	(2.586)	(4.572)	(2.543)	(4.529)	(2.568)	(4.522)
Tenure at level(t-1)*100	2.296***	0.295	2.408***	0.401	2.041***	0.153	2.007***	0.265
	(0.734)	(0.862)	(0.740)	(0.853)	(0.712)	(0.847)	(0.715)	(0.844)
Tenure at $level(t-1)^2$*10000	-16.406***	5.142	-16.802***	4.659	-14.768**	5.788	-14.641**	5.293
	(6.047)	(6.413)	(6.061)	(6.369)	(5.836)	(6.296)	(5.822)	(6.286)
Rating(t-1)	0.029***	0.018***	0.027***	0.013**	0.026***	0.017***	0.026***	0.013***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Average turnover rate	0.085	0.078	0.085	0.078	0.085	0.078	0.085	0.078
	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)
Level(t-1) indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5644	7107	5644	7107	5644	7107	5644	7107
Pseudo R-sq.	0.030	0.039	0.031	0.043	0.038	0.043	0.038	0.046
Log likelihood	-1590.115	-1866.556	-1589.520	-1858.661	-1577.459	-1859.190	-1577.415	-1854.394

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low level subsample contains promotions from job levels 1 and 2 while the high level subsample contains promotions from job levels 3 through 7; for all the regressions average marginal effects are calculated.

APPENDICES

APPENDX 1. PROOF OF PROPOSITION 1.1

Consider first the second period. Since period 2 is the last period of production, each worker must choose the lowest effort level in equilibrium, i.e. $e_i^2 = e_j^2 = e_2^* = 0$. Because of market competition, the market wage W_m equals each worker's expected productivity in period 2. That is, $W_m^* = b$.

In period 1, each worker chooses an effort level to maximize her expected lifetime utility conditional on the wage offers, while each firm chooses wages to maximize each worker's expected utility subject to a zero profit constraint and that her effort is a best response to the wages. Because of the assumptions $C'(0) = 0$ and $C" > 0$, if a solution exists, we know it must be an interior solution.

We now write down each worker i's expected utility function and each firm's expected profit function. In particular, the utility function can be written as follows.

$$EU_i = W_Y + P(y_i^1 > y_j^1)\{P(\alpha_i < W_P - W_m)W_P + [1 - P(\alpha_i < W_P - W_m)]W_m\} + [1 - P(y_i^1 > y_j^1)]\{P(\alpha_i < W_{NP} - W_m)W_{NP} + [1 - P(\alpha_i < W_{NP} - W_m)]W_m\} - E[\alpha_i + C(e_i^1)] - \{P(y_i^1 > y_j^1)\int_{-a}^{W_P - W_m} xu(x)dx + [1 - P(y_i^1 > y_j^1)]\int_{-a}^{W_{NP} - W_m} xu(x)dx\} \quad \text{(A1.1)}$$

In the expression above, $E[\alpha_i + C(e_i^1)] = C(e_i^1)$. Let $G(.)$ and $g(.)$ denote the cumulative distribution function and the density function of $\epsilon_{jt} - \epsilon_{it}$, respectively, where $g(0) > 0$ and $G(0) = \frac{1}{2}$. Therefore, the probability of worker i winning the tournament can be expressed as follows. $P(\mathrm{y}_\mathrm{i}^1 > \mathrm{y}_\mathrm{j}^1) = G(e_i^1 - \mathrm{e}_\mathrm{j}^1)$. To simplify notation, define $F_l^i \equiv P(\alpha_\mathrm{i} < W_l - W_m) =$

$\frac{W_l - b}{2a} + \frac{1}{2}$, where $l \in \{P, NP\}$. Due to the assumption that match qualities are uniformly distributed on the interval $[-a, a]$, (A1.1) can be expressed in the following way.

$$EU_i = W_Y + G(e_i^1 - e_j^1)\{F_P W_P + (1 - F_P)W_m\} + [1 - G(e_i^1 - e_j^1)]\{F_{NP} W_{NP} + (1 - F_{NP})W_m\} - C(e_i^1) - G(e_i^1 - e_j^1)\left(\frac{W_P - W_{NP}}{2} - W_m\right) - \frac{W_{NP} - W_m - a}{2} - C(e_i^1) \quad \text{(A1.2)}$$

Now consider the firms' profit function. Because of the assumption that $n_f > 2n_w$, we know in equilibrium each firm earns zero expected profit. This zero profit condition can be expressed as (A1.3).

$$E\Pi = E(y_i^1) + \{G(e_i^1 - e_j^1)F_P^i + [1 - G(e_i^1 - e_j^1)]F_{NP}^i\}E(y_i^2) + E(y_j^1) + \{[1 - G(e_i^1 - e_j^1)]F_P^j + G(e_i^1 - e_j^1)F_{NP}^j\}E(y_j^2) - \{G(e_i^1 - e_j^1)F_P^i + [1 - G(e_i^1 - e_j^1)]F_P^j\}W_P - \{[1 - G(e_i^1 - e_j^1)]F_{NP}^i + G(e_i^1 - e_j^1)F_{NP}^j\}W_{NP} - W_Y - W_Y = 0 \quad \text{(A1.3)}$$

In expression (A1.3), y_i^t denotes each worker i's output level in period t. Based on the utility function and the profit function above, the maximization problem can be set up as the following.

$$\max_{\{W_Y, W_P, W_{NP}, e_i^1\}} EU_i \quad \text{(A1.2)}$$

$$\text{st.} \, E\Pi = 0 \quad \text{(A1.3)}$$

$$e_i^1 \in \underset{\{e_i^1 \geq 0\}}{\text{argmax}} \, EU_i, \text{ given } W_Y, W_P, W_{NP}, \text{ and } e_j^1 \quad \text{(A1.4)}$$

We now solve for the maximization problem. First, recall that $F(y, e)$ satisfies both the MLRC property and the CDFC condition.[92] According to Rogerson (1985), we can solve for the

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[92] See footnote 13 for details on the MLRC property and the CDFC condition.

maximization problem using the first order approach. That is, the problem defined by (A1.2) to (A1.4) is equivalent to the relaxed program defined by (A1.2), (A1.3) and (A1.5).

$$\max_{\{W_Y, W_P, W_{NP}, e_i^1\}} EU_i \tag{A1.2}$$

$$\text{st.}\, E\Pi = 0 \tag{A1.3}$$

$$\frac{\partial EU_i}{\partial e_i^1} = 0, \text{ given } W_Y,\ W_P,\ W_{NP}, \text{ and } e_j^1 \tag{A1.5}$$

In addition, (A1.5) can be rewritten as (A1.6).

$$g\left(e_i^1 - e_j^1\right)\left\{F_P(W_P - b) - F_{NP}(W_{NP} - b) - \frac{W_P - W_{NP}}{2} + b\right\} = C'(e_i^1) \tag{A1.6}$$

Note that condition (A1.6) defines a worker's optimal effort choice as the best response function of the wages W_P, W_{NP}, and W_Y and the other worker's first period effort choice e_j^1.

Given the symmetry of e_i^1 and e_j^1 in (A1.2), (A1.3) and (A1.6), we know that if a solution exists, it should be a symmetric Nash equilibrium in which each worker in a tournament exerts the same level of first period effort and has a probability of $\frac{1}{2}$ of being promoted. Let e_1^* denote this equilibrium effort level. Due to the symmetry between the two workers, we can simplify conditions (A1.2), (A1.3), and (A1.6) as (A1.7), (A1.8), and (A1.9), respectively.

$$EU_i = W_\text{Y} + \frac{1}{2}\{F_P W_P + (1 - F_P)W_m\} + \frac{1}{2}\{F_{NP} W_{NP} + (1 - F_P)W_m\} - C(e_1^*) - \frac{1}{2}\left(\frac{W_P - W_{NP}}{2} - b\right) - \frac{W_{NP} - b - a}{2} = W_\text{Y} + \frac{1}{2}F_P(W_P - b) + \frac{1}{2}F_{NP}(W_{NP} - b) - \frac{1}{4}W_P - \frac{1}{4}W_{NP} + 2b + \frac{1}{2}a - C(e_1^*)$$

(A1.7)

$$E\Pi = 2b + 2e_1^* - 2W_\text{Y} - F_P(W_P - b) - F_{NP}(W_{NP} - b) = 0 \tag{A1.8}$$

$$g(0)\left\{F_P(W_P-b)-F_{NP}(W_{NP}-b)-\frac{W_P-W_{NP}}{2}+b\right\}=C'(e_1^*)$$

Or equivalently,

$$g(0)\left\{\frac{(W_P-b)^2}{2a}-\frac{(W_{NP}-b)^2}{2a}+b\right\}=C'(e_1^*) \quad \text{(A1.9)}$$

From (A1.9), we can solve for e_1^* as a function of the period two wages W_P and W_{NP}, i.e.,

$$e_1^*=h(W_P-b,W_{NP}-b)=C'^{-1}\{g(0)\left\{\frac{(W_P-b)^2}{2a}-\frac{(W_{NP}-b)^2}{2a}+b\right\}\}. \quad \text{(A1.10)}$$

Due to the fact that $C">0$, we know that C' is both invertible and strictly increasing, and so is C'^{-1}. For notational simplicity, define $D\equiv C'^{-1}$. Therefore, D satisfies $D'>0$. Plugging (A1.10) into (A1.8), the zero profit condition is simplified to the following equation.

$$2b+2h(W_P-b,W_{NP}-b)-2W_{\mathrm{Y}}-F_P(W_P-b)-F_{NP}(W_{NP}-b)=0 \quad \text{(A1.11)}$$

Solving W_Y from (A1.11), we have (A1.12).

$$2W_{\mathrm{Y}}=2b+2h(W_P-b,W_{NP}-b)-F_P(W_P-b)-F_{NP}(W_{NP}-b) \quad \text{(A1.12)}$$

Define $x_l\equiv W_l-b, l\in\{P,NP\}$ and plug (A1.12) into (A1.7). The maximization problem is now reduced to the problem characterized by (A1.13).

$$\max_{\{x_P,x_{NP}\}} h(x_P,x_{NP})-\frac{x_P}{4}-\frac{x_{NP}}{4}-C(h(x_P,x_{NP})) \quad \text{(A1.13)}$$

Define $h_P\equiv\frac{\partial h(x_P,x_{NP})}{\partial x_P}$ and $h_{NP}\equiv\frac{\partial h(x_P,x_{NP})}{\partial x_{NP}}$. From (A1.10) we now have (A1.14).

$$\begin{aligned} \mathrm{h_P}&=\mathrm{D}'\{\mathrm{g}(0)\left\{\frac{(\mathrm{W_P-b})^2}{2\mathrm{a}}-\frac{(\mathrm{W_{NP}-b})^2}{2\mathrm{a}}+\mathrm{b}\right\}\}\frac{\mathrm{W_P-b}}{a}\\ h_{NP}&=\mathrm{D}'\{\mathrm{g}(0)\left\{\frac{(\mathrm{W_P-b})^2}{2\mathrm{a}}-\frac{(\mathrm{W_{NP}-b})^2}{2\mathrm{a}}+\mathrm{b}\right\}\}(-1)\frac{W_{NP}-b}{a}\end{aligned} \quad \text{(A1.14)}$$

Further, taking derivatives with respect to x_P and x_{NP} in (A1.13), respectively, we have the first order conditions (A1.15) and (A1.16).

$$F.O.C.(x_P): h_P^*[1 - C'(e_1^*)] = \frac{1}{4} \tag{A1.15}$$

$$F.O.C.(x_{NP}): h_{NP}^*[1 - C'(e_1^*)] = \frac{1}{4} \tag{A1.16}$$

Conditions (A1.15) and (A1.16) yield

$$h_P^* = h_{NP}^* \neq 0, \tag{A1.17}$$

while condition (A1.14) says

$$\frac{h_P^*}{h_{NP}^*} = -\frac{x_P^*}{x_{NP}^*}. \tag{A1.18}$$

Therefore, (A1.17) together with (A1.18) tell us that $x_P^* + x_{NP}^* = 0$, i.e.,

$$W_{NP}^* + W_P^* = 2b. \tag{A1.19}$$

We now consider the equilibrium wages. First consider the relationship between W_P^* and W_{NP}^*. Suppose $W_P^* \leq W_{NP}^*$. Then we know that workers would exert zero effort in period 1, i.e., $e_1^* = 0$. Focusing on interior solutions, the equilibrium wages must satisfy $W_P^* > W_{NP}^*$. This wage relationship together with (A1.19) indicates that

$$W_P^* > b > W_{NP}^*. \tag{A1.20}$$

In addition, one can solve for the equilibrium first period wage W_Y from (A1.12) where the second period wages are at the equilibrium levels. As a result, $W_Y^* = b + e_1^* - \frac{1}{4}[\frac{(W_P^* - b)^2}{a} + (W_P^* - b) + \frac{(W_{NP}^* - b)^2}{a} + (W_{NP}^* - b)]$. Note that because of condition (A1.19), $W_P^* - b + W_{NP}^* - b = 0$. Therefore, W_Y^* can be rewritten as $W_Y^* = b + e_1^* - \frac{1}{4}[\frac{(W_P^* - b)^2}{a} + \frac{(W_{NP}^* - b)^2}{a}]$. Therefore, $W_Y^* < b + e_1^*$, i.e., due to the fact that firms offer higher promotion wages and the promoted workers are more likely to stay, each firm makes strictly negative expected second period profit from a worker. As a result, the first period wage is below the young workers' expected productivity in period 1.

Next, consider the level of first period effort in equilibrium. Instead of solving for it explicitly, I focus on the comparison of that to the efficient effort level. First, condition (A1.17) tells us that $h_P^* = h_{NP}^*$, while condition (A1.20) says that $W_P^* - b > 0$ and $W_{NP}^* - b < 0$. Because $D' > 0$, the inequalities above together with (A1.14) indicate that $h_P^* = h_{NP}^* > 0$. Additionally, conditions (A1.15) and (A1.16) indicate that $C'(e_1^*) < 1$, i.e., $e_1^* < e_1^S$. In other words, the equilibrium level of first period effort is below the efficient level.

Lastly, let us compare the equilibrium turnover rates to the efficient turnover rate. First, note that turnover is efficient if a worker quits when her match quality with the current firm is worse than her expected match with a potential employer. That is, turnover is efficient if and only if $W_l^* = W_m^* = b, l \in \{P, NP\}$. Further, there is excessive (insufficient) turnover if and only if $W_l^* < (>) b, l \in \{P, NP\}$. Recall that P^S, P_P^* and P_{NP}^* denote the efficient and equilibrium turnover rates for the promoted and the non promoted workers. According to the previous analysis, condition (A1.20) indicates that $P_P^* < P_S < P_{NP}^*$, i.e., there is insufficient turnover for the promoted workers while excessive turnover for the non-promoted workers in equilibrium (QED).

APPENDIX 2. PROOF OF PROPOSITION 1.3

Consider first the second period. Recall that θ' denotes the ability level for efficient promotion.[93] Let W_m^j and W_i^j denote the market wage offer and the current firm's wage offer to each worker i with job assignment j. Let θ^+ denote the ability level so that a firm is indifferent between promoting a worker with such ability and not promoting a worker with such ability. That is, the expected profit from promoting the worker with ability θ^+ equals that from not promoting the worker. As a result, θ^+ must satisfy the condition

$$P(\alpha_i \leq W_i^1 - W_m^1)[(1+k)(d_1 + c_1\theta^+) - W_i^1] = P(\alpha_i \leq W_i^2 - W_m^2)[(1+k)(d_2 + c_2\theta^+) - W_i^2] \,. \tag{A2.1}$$

Therefore, a worker with ability $\theta_i > \theta^+$ will be promoted to job 2 while a worker with ability $\theta_i \leq \theta^+$ will stay at job 1 in the second period.

We now characterize the market wages. Note first that the market wage equals the worker's expected productivity at the job the worker is assigned to conditional on the fact that the worker switched employers. Since ability is not observable to outside firms, outside firms use the promotion decision as a signal of ability and update their beliefs regarding ability upon observing each worker's job assignment at her current employer. Let $\alpha_i^j(\theta_i)$ denote the cutoff match quality for worker i with ability θ_i at job j such that a worker will switch employers if her match quality is worse than $\alpha_i^j(\theta_i)$.[94] In addition, let θ_e^j denote the expected ability of the workers who were assigned to job j and switched employers. That is,

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[93] To ensure θ' exists and that $\theta' > \bar{\theta}$, assume $\frac{d_1 - d_2}{c_2 - c_1} \in (\frac{\theta_L + \theta_H}{2}, \theta_H)$.

[94] That is, worker i will switch employers if $\alpha_i \geq \alpha_i^j(\theta_i)$.

$$\theta_e^2 = \int_{\theta^+}^{\theta_H} \theta_i \frac{a-\alpha_i^2(\theta_i)}{\int_{\theta^+}^{\theta_H} a-\alpha_i^2(\theta_i)\ d\theta_i} d\theta_i, \text{ and } \theta_e^1 = \int_{\theta_L}^{\theta^+} \theta_i \frac{a-\alpha_i^1(\theta_i)}{\int_{\theta_L}^{\theta^+} a-\alpha_i^1(\theta_i)\ d\theta_i} d\theta_i. \quad \text{(A2.2)}$$

[95]

In other words, the expected ability of each group of workers equals the weighted average of the ability levels by the probability of a worker switching employers given that ability level. As a result, the market wage offer to the workers who were promoted and left and that to the workers who were not promoted and left equal $W_m^2 = d_2 + c_2\theta_e^2$ and $W_m^1 = d_1 + c_1\theta_e^1$, respectively.

We now consider the current firm's problem regarding each worker i. First consider the amount of rent the current firm extracts from worker i. Given the worker's ability and the market wage offer, the current firm's problem is to choose a wage W_i^j to maximize its expected profit. Since worker i only stays at the current firm if her expected cost from staying is less than or equal to her expected benefit from staying, each firm's expected profit function is given by $P(\alpha_i \leq W_i^j - W_m^j)[(1+k)(d_j + c_j\theta_i) - W_i^j]$. Let Δ_i^j denote the difference between the current firm's wage offer and the market wage offer to each worker i, i.e., $\Delta_i^j \equiv (W_i^j - W_m^j)$. Because $\alpha_i^j(\theta_i)$ denotes the cutoff match quality for worker i at job j such that the worker leaves if her match with the current firm is worse than $\alpha_i^j(\theta_i)$, we know by definition

$$\alpha_i^j(\theta_i) = \Delta_i^j\ . \quad \text{(A2.3)}$$

Based on the notation above, each firm's expected profit can be written as (A2.4).

$$P(\alpha_i \leq \Delta_i^j)[(1+k)(d_j + c_j\theta_i) - (W_m^j + \Delta_i^j)], \text{ where } P(\alpha_i \leq \Delta_i^j) = \frac{\Delta_i^j + a}{2a} \quad \text{(A2.4)}$$

Therefore, each firm's problem is to choose Δ_i^j to maximize the expected profit in (A2.4). Solving this maximization problem we have the difference between the non-turnover and the

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[95] Here I assume outside firms make consistent job assignment decisions with each worker's current employer. I prove later that this is indeed the optimal strategy for outside firms in equilibrium.

turnover wages equals $\Delta_i^{j*} = \frac{1}{2}[(1+k)(d_j + c_j\theta_i) - a - W_m^j]$ in equilibrium, where $j \in \{1,2\}$. Therefore, the second period wage $W_i^j = W_m^j + \Delta_i^{j*} = \frac{1}{2}\left[(1+k)(d_j + c_j\theta_i) - a + W_m^j\right] = \frac{1}{2}\left[(1+k)(d_j + c_j\theta_i) - a + \left(d_j + c_j\theta_e^j\right)\right]$, where $j \in \{1,2\}$.

I now calculate the turnover rate for each worker i given the equilibrium rent Δ_i^{j*}. Let x_i^j denote the difference between the efficient ability of an old worker i and the market expected ability of this worker at job j. That is,

$$x_i^j = (1+k)\theta_i - \theta_e^j, j \in \{1,2\}. \quad \text{(A2.5)}$$

Later I refer to x_i^j as the ability distance. Based on the definition of x_i^j, Δ_i^{j*} can be rewritten as (A2.6).

$$\Delta_i^{j*} = \frac{1}{2}\left(kd_j - a\right) + \frac{c_j}{2}x_i^j, j \in \{1,2\}. \quad \text{(A2.6)}$$

Therefore, the second period wage $W_i^j = W_m^j + \Delta_i^{j*} = W_m^j + \frac{1}{2}\left(kd_j - a\right) + \frac{c_j}{2}x_i^j$ increases in the ability distance $x_i^j, j \in \{1,2\}$. Also, condition (A2.6) tells us that the probability of staying for worker i at job j equals $P\left(\alpha_i \leq \Delta_i^{j*}\right) = \frac{1}{4a}\left(kd_j + a\right) + \frac{c_j}{4a}x_i^j, j \in \{1,2\}$. Let P_i^j denote the turnover rate for worker i at job j. We know

$$P_i^j = 1 - P\left(\alpha_i \leq \Delta_i^{j*}\right) = \frac{1}{4a}\left(3a - kd_j\right) - \frac{c_j}{4a}x_i^j. \quad \text{(A2.7)}$$

That is, the turnover rate decreases in the ability distance x_i^j.

I now demonstrate that, to prove the average turnover rate of the promoted workers is higher than that of the non-promoted workers, it is sufficient to show the distance between the market expected ability and the mean ability levels of the promoted workers is less than that of the non-promoted workers, where the mean ability level is calculated based on a uniform distribution. Let

AP^j denote the average turnover rate of the workers at job j, where $j \in \{1,2\}$. Therefore, the goal here is to show $AP^2 > AP^1$. Assume first there is no firm specific human capital, i.e., $k = 0$. From equation (A2.7) we know that $P_i^1 = \frac{3}{4} - \frac{c_1}{4a} x_i^1$ and that $P_i^2 = \frac{3}{4} - \frac{c_2}{4a} x_i^1$. In addition, assume that the return to effort at the two jobs is the same, i.e., $c_1 = c_2$. As a result, to show $AP^2 > AP^1$, where $AP^j = \int P_i^j d\theta_i$, it is sufficient to show

$$\int_{\theta_L}^{\theta^+} x_i^1 d\theta_i > \int_{\theta^+}^{\theta_H} x_i^2 d\theta_i. \tag{A2.8}$$

To prove condition (A2.8) holds, let us first solve for $\int_{\theta_L}^{\theta^+} x_i^1 d\theta_i$ and $\int_{\theta^+}^{\theta_H} x_i^2 d\theta_i$ explicitly. From equation (A2.5), we know (A2.9) and (A2.10) hold.

$$\int_{\theta_L}^{\theta^+} x_i^1 d\theta_i = (\theta^+ - \theta_L)[(1+k)\frac{\theta^+ + \theta_L}{2} - \theta_e^1] \tag{A2.9}$$

$$\int_{\theta^+}^{\theta_H} x_i^2 d\theta_i = (\theta_H - \theta^+)[(1+k)\frac{\theta^+ + \theta_H}{2} - \theta_e^2] \tag{A2.10}$$

Let $\overline{\theta_1}$ and $\overline{\theta_2}$ denote the average ability level of worker i at jobs 1 and 2, respectively, where θ_i is uniformly distributed on the relevant interval. That is, $\overline{\theta_1} = \frac{\theta^+ + \theta_L}{2}$ and $\overline{\theta_2} = \frac{\theta^+ + \theta_H}{2}$. As a result, conditions (A2.9) and (A2.10) can be rewritten as conditions (A2.11) and (A2.12).

$$\int_{\theta_L}^{\theta^+} x_i^1 d\theta_i = (\theta^+ - \theta_L)[(1+k)\overline{\theta_L} - \theta_e^1] \tag{A2.11}$$

$$\int_{\theta^+}^{\theta_H} x_i^2 d\theta_i = (\theta_H - \theta^+)[(1+k)\overline{\theta_H} - \theta_e^2] \tag{A2.12}$$

Suppose $\theta^+ > \theta'$. Based on the assumption that $\theta' > \bar{\theta}$, we have $\theta^+ - \theta_L > \theta_H - \theta^+$. Therefore, to show condition (A2.8) holds, it is sufficient to show $\overline{\theta_1} - \theta_e^1 > \overline{\theta_2} - \theta_e^2$. See Figure 9 below for the relationship among the critical ability levels.

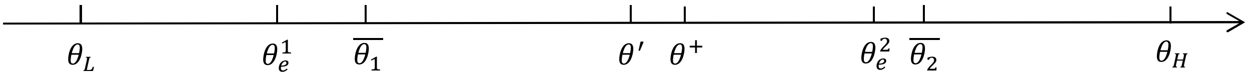

Figure 9. Relationship of the Ability Levels in the Signaling Model

I now prove $\overline{\theta_1} - \theta_e^1 > \overline{\theta_2} - \theta_e^2$. First, let $L_j(\theta_i)$ denote the updated market belief of each worker i's probability of leaving conditional on her job assignment j, i.e., $L_j(\theta_i) = \frac{a-\alpha_i^j(\theta_i)}{\int_{I_j} a-\alpha_i^j(\theta_i)\ d\theta_i}$, where $I_1 = [\theta_L, \theta^+]$ and $I_2 = [\theta^+, \theta_H]$, $j \in \{1,2\}$. Further, let $d(I_j)$ denote the length of the interval I_j. According to (A2.11) and (A2.12), we know that

$L_j(\theta_i) = \frac{3a-kd_j-c_j[(1+k)\theta_i-\theta_e^j]}{d(I_j)[3a-sd_j-c_j[(1+k)\overline{\theta_J}-\theta_e^j]}$, where $j \in \{1,2\}$. (A2.13)

For simplicity, define $f_j(\theta_i) \equiv 3a - kd_j - c_j[(1+k)\theta_i - \theta_e^j]$. According to this definition, $f_j(\theta_i)$ is an increasing function of θ_i. Also, we can now rewrite $L_j(\theta_i)$ as $L_j(\theta_i) = \frac{f_j(\theta_i)}{d(I_j)f_j(\overline{\theta_J})}$. Therefore, according to condition (A2.13), the market expected ability of the workers assigned to job j equals $\theta_e^j = \int_{I_j} \theta_i L_j(\theta_i) d\theta_i = \overline{\theta_J} - \frac{1}{f(\overline{\theta_J})}(1+k)c_j\frac{d(I_j)^2}{12}$ and hence the distance between the mean ability and the market expected ability levels equals $\overline{\theta_J} - \theta_e^j = \frac{1}{f(\overline{\theta_J})}(1+k)c_j\frac{d(I_j)^2}{12}$. Because $f_j(\theta_i)$ increases in θ_i, we know $f(\overline{\theta_1}) < f(\overline{\theta_2})$, i.e., $\frac{1}{f(\overline{\theta_1})} > \frac{1}{f(\overline{\theta_2})}$. Additionally, because $\theta^+ - \theta_L > \theta_H - \theta^+$, we know $d(I_1) > d(I_2)$, i.e., $d(I_1)^2 > d(I_2)^2$. Lastly, based on the assumption that in the limit as $c_1 - c_2$ approaches 0, we have $\overline{\theta_1} - \theta_e^1 > \overline{\theta_2} - \theta_e^2$. As a result, we have the average turnover rate of the promoted workers is higher than that of the non-promoted workers, i.e., $AP^2 > AP^1$.

Let v denote the ratio of the return to ability at job 2 to that at job 1, i.e., $c_2 = vc_1, v > 1$.

Note that because $AP^j, j \in \{1,2\}$ is a continuous function of k and the return to ability at job j, c_j,we know that there exists an $\varepsilon > 0$ that is small enough and a $\eta > 0$ that is small enough so that $\forall k \in (0, \varepsilon)$ and $\forall v \in (1, 1+\eta)$, the condition $AP^2 > AP^1$ holds. That is, if the firm specific human capital is sufficiently small and the return to ability at the two jobs are sufficiently close to each other, it is always true that the average turnover rate of the promoted workers is higher than that of the non-promoted workers.

I now consider the relationship between θ^+ and θ'. First, based on the equilibrium solutions to the wages, condition (A2.1) is equivalent to $kd_1 + c_1[(1+k)\theta^+ - \theta_e^1] = kd_2 + c_2[(1+k)\theta^+ - \theta_e^2]$. Solving for θ^+ from the previous condition we have

$$\theta^+ = \frac{k(d_1-d_2)+(c_2\theta_e^2-c_1\theta_e^1)}{(1+k)(c_2-c_1)}. \quad \text{(A2.14)}$$

To compare θ^+ with θ', I subtract θ' from equation (A2.14). As a result, we have (A2.15).

$$\theta^+ - \theta' = \frac{(d_2+c_2\theta_e^2)-(d_1+c_1\theta_e^1)}{(1+k)(c_2-c_1)} \quad \text{(A2.15)}$$

Note that the denominator of condition (A2.15) is strictly positive and the numerator of condition (A2.15) is the difference between the market expected productivity of the promoted workers and that of the non-promoted workers. As a result, the comparison of θ^+ and θ' is equivalent to the comparison of the two expected productivities.

Consider the following two cases. First, suppose $\theta^+ = \theta'$, i.e.,

$$d_2 + c_2\theta_e^2 = d_1 + c_1\theta_e^1. \quad \text{(A2.16)}$$

According to the definition of θ', we know

$$d_2 + c_2\theta' = d_1 + c_1\theta'. \quad \text{(A2.17)}$$

Subtracting condition (A2.17) from condition (A2.16) we have (A2.18).

$$c_2(\theta_e^2 - \theta') = c_1(\theta_e^1 - \theta') \quad \text{(A2.18)}$$

However, since $\theta_e^2 > \theta' > \theta_e^1$, the left hand side of condition (A2.18) is strictly positive while the right hand side of this condition is strictly negative. Hence, we have a contradiction.

Second, suppose $\theta_L \leq \theta^+ < \theta'$. Now there are two possible relationships between the market expected abilities and the efficient ability for promotion. Suppose first that $\theta_e^1 < \theta' < \theta_e^2$, then similar to the analysis in the previous case, we have a contradiction to condition (A2.18). If, on the other hand, $\theta_e^1 < \theta_e^2 < \theta'$, it is then optimal for the market to assign all the workers who switched employers to the low level job. As a result, outside firms are only willing to pay a single wage to the workers who switched employers, which equals the expected productivity of the worker evaluated at the lower expected ability level, i.e., $W_m^1 = W_m^2 = d_1 + c_1\theta_e^1$. The previous analysis suggests that the promotion signal has no value to the outside firms and hence should not bid up the wage paid to the promoted workers. As a result, the current firm of each worker will promote the worker in an efficient fashion, i.e., promote the worker if and only if this worker's ability θ_i is above the efficient ability for promotion θ', and not otherwise. This in turn indicates $\theta^+ = \theta'$, which leads to a contradiction to the case being considered here.

From the discussion of the two cases above we know it must be true in equilibrium that $\theta^+ > \theta'$. That is, similar to the discussion in Ghosh and Waldman (2010), because promotion signals a worker's high ability and hence bids up the market wage offer to the promoted workers, a firm is only willing to promote this worker if her ability is high enough. This is to ensure that the increase in productivity is sufficient to cover the associated increase in the wage.

As a final note, $\theta^+ > \theta'$ tells us that it is optimal for the outside firms to align their job assignment decisions with the current firm. That is, to assign a worker to the high level job if the worker was promoted and switched employers, and to the low level job if she was not promoted and switched employers.

Lastly, consider the first period wage W_Y. Because of the free entry assumption, we know that each firm makes zero expected profit in equilibrium, where the expected profit can be expressed as follows.

$$E\Pi_i = (d_1 + c_1\bar{\theta}) - W_Y + \frac{\theta^+ - \theta_L}{\theta_H - \theta_L} P(\alpha_i \leq \Delta_i^{1*})[(1+k)(d_1 + c_1\theta_i) - W_m^1 - \Delta_i^{1*}] + \frac{\theta_H - \theta^+}{\theta_H - \theta_L} P(\alpha_i \leq \Delta_i^{2*})[(1+k)(d_2 + c_2\theta_i) - W_m^2 - \Delta_i^{2*}] \quad \text{(A2.19)}$$

Further, $E\Pi_i$ can be rewritten as condition (A2.20).

$$E\Pi_i = P\left(\alpha_i \leq \Delta_i^{j*}\right)\left[(1+k)\left(d_j + c_j\theta_i\right) - W_m^j - \Delta_i^{j*}\right] = \frac{1}{8a}\left[\left(kd_j + a\right) + c_j\left[(1+k)\theta_i - \theta_e^j\right]\right]^2 \geq 0, j \in \{1,2\} \quad \text{(A2.20)}$$

That is, the expected profit from each worker i is non-negative. Therefore, the expected second period profit must be strictly positive in equilibrium.[96] Because the first period wage W_Y^* satisfies the zero profit condition, we know that it must be higher than the young workers' expected output in period 1. That is, $W_Y^* > d_1 + c_1\bar{\theta}$ (QED).

[96] This is based on the assumption that not all the workers a firm hires have abilities that equal the market expected ability level $\theta_e^j, j \in \{1,2\}$.

APPENDIX 3. PROOF OF PROPOSITION 2.1

Below I solve the utility maximization problem in the extension of the tournament model with a focus on the symmetric perfect Bayes Nash equilibrium. Consider first the second period. Similar to the original model, because period 2 is the last period of production, workers choose the lowest effort possible and outside firms pay the workers according to their expected second period outputs. Because the human capital is firm specific, each worker will earn the market wage of $W_m = b$ in equilibrium.

In the first period, each worker chooses an effort level to maximize her expected lifetime utility given the wages. On the other hand, each firm chooses wages to maximize a worker's expected utility subject to a zero profit constraint and the fact that each worker chooses effort to maximize her expected lifetime utility given the wages.

Before solving the problem in more detail, it is helpful to first consider the relationship between the human capital and non-human capital wages. Recall from the analysis of the original extension of the tournament model that each firm chooses second period wages to minimize three types of inefficiencies, i.e., the inefficiency from the first period effort, the insufficient turnover of the promoted workers, and the excessive turnover of the non-promoted workers. This remains the case in the further extension of the model. However, what changes is that there are now two pairs of second period wages, where there is a distinct pair for each human capital outcome. Let W_l^k and W_l^0 denote the human capital and the non-human capital wages for the worker with the job assignment l, where $l \in \{P, NP\}$. Because the human capital workers contribute higher productivities to their current employers, we should expect to see that each firm has a stronger incentive to minimize the inefficiencies from turnover of the workers with the human capital. That is, the wage spread for the workers with the human capital is smaller than that for the workers without the human capital, i.e., $W_P^k - W_{NP}^k < W_P^0 - W_{NP}^0$.

Now let us characterize the efficient effort level and turnover rate. Following the notation in the original extension of the tournament model, let $G(.)$ and $g(.)$ denote the cumulative distribution function and the density function of the random variable $\varepsilon_j^t - \varepsilon_i^t$ and let $C(e_i^t)$ denote the disutility of effort. In addition, $C(e_i^t)$ satisfies the conditions $C' \geq 0, C" > 0$, $C'(0) = 0$, and $C(0) = 0$.

To begin, note that the level of efficient effort remains the same as in the original model. Specifically, it equates the marginal cost of effort to the marginal revenue, i.e., $C'(e_1^S) = 1$. However, the efficient turnover rate now varies with the human capital outcome. Let P_S^r denote the efficient turnover rate of the worker with the human capital outcome $r \in \{k, 0\}$. Then we have $P_S^0 = P(\alpha_i \geq 0)$ while $P_S^k = P(\alpha_i \geq k)$. That is, it is efficient for a non-human capital worker to leave if her match with the current employer is worse than the expected match with a potential employer, while it is efficient for a human capital worker to leave when her match quality is more than the extra productivity she brings to the firm, which equals the amount of the firm specific human capital k.

We now solve for the first period wages and turnover rates explicitly. Let us first write down the expected utility function of worker i. Below let $F_l^r \equiv \frac{W_l^r - W_m}{2a} + \frac{1}{2}$ denote the probability of staying for the human capital and non-human capital workers under each job assignment l and human capital outcome r, $l \in \{P, NP\}$ and $r \in \{k, 0\}$.

$$EU_i = W_Y + G\left(e_i^1 - e_j^1\right)\left\{\delta\left[F_P^k W_P^k + \left(1 - F_P^k\right)W_m\right] + (1-\delta)[F_P^0 W_P^0 + (1 - F_P^0)W_m]\right\} +$$

$$\left[1 - G\left(e_i^1 - e_j^1\right)\right]\left\{\delta\left[F_{NP}^k W_{NP}^k + \left(1 - F_{NP}^k\right)W_m\right] + (1-\delta)[F_{NP}^0 W_{NP}^0 + (1 - F_{NP}^0)W_m]\right\} -$$

$C(e_i^1) - G(e_i^1 - e_j^1)\left[\delta\left(\frac{W_P^k - W_m - a}{2}\right) + (1-\delta)\left(\frac{W_P^0 - W_m - a}{2}\right)\right] + [1 -$

$G(e_i^1 - e_j^1)][\delta(\frac{W_{NP}^k - W_m - a}{2}) + (1-\delta)\left(\frac{W_{NP}^0 - W_m - a}{2}\right)]$ (A3.1)

Plugging in $W_m = b$ and simplifying (A3.1) we have the following expression for the expected utility function.

$EU_i =$

$W_Y + G(e_i^1 - e_j^1)\delta\frac{(W_P^k - b)^2}{2a} + G(e_i^1 - e_j^1)(1-\delta)\frac{(W_P^0 - b)^2}{2a} + \left[1 - G(e_i^1 - e_j^1)\right]\delta\frac{(W_{NP}^k - b)^2}{2a} +$

$\left[1 - G(e_i^1 - e_j^1)\right](1-\delta)\frac{(W_{NP}^0 - b)^2}{2a} + b + \frac{a}{2} - C(e_i^1)$ [97] (A3.2)

Define $x_l^r \equiv W_l^r - b,\ l \in \{P, NP\}$ and $r \in \{k, 0\}$. Also, taking the first order condition of (A3.2) with respect to e_i^1 yields (A3.3).

$g(e_i^1 - e_j^1)\{\delta\left({x_P^k}^2 - {x_{NP}^k}^2\right) + (1-\delta)\left({x_P^0}^2 - {x_{NP}^0}^2\right)\} = 2aC'(e_i^1)$ (A3.3)

Now we consider the firms' expected profit function, where the expected productivities in period 2 vary with the human capital outcome. Building on the zero profit condition in (A1.1), the zero profit condition can now be written as the following.

$E\Pi = E(y_i^1) + E(y_j^1) - W_Y - W_Y + \delta\{\{G(e_i^1 - e_j^1)F_P^{ki} + \left[1 - G(e_i^1 - e_j^1)\right]F_{NP}^{ki}\}E(y_i^{2k}) +$

$\{\left[1 - G(e_i^1 - e_j^1)\right]F_P^{kj} + G(e_i^1 - e_j^1)F_{NP}^{kj}\}E(y_j^{2k}) -$

$\{G(e_i^1 - e_j^1)F_P^{ki} + \left[1 - G(e_i^1 - e_j^1)\right]F_P^{kj}\}\, W_P^k -$

$\{\left[1 - G(e_i^1 - e_j^1)\right]F_{NP}^{ki} + G(e_i^1 - e_j^1)F_{NP}^{kj}\}W_{NP}^k\} + (1-\delta)\{\{G(e_i^1 - e_j^1)F_P^{0,i} + \left[1 - G(e_i^1 -\right.$

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[97] In the specification for utility maximization below I ignore the term $b + \frac{a}{2}$ because it is a constant.

$e_j^1)]F_{NP}^{0,i}\}E(y_i^{2,0}) + \{[1 - G(e_i^1 - e_j^1)]F_P^{0,j} + G(e_i^1 - e_j^1)F_{NP}^{0,j}\}E(y_j^{2,0}) - \{G(e_i^1 - e_j^1)F_P^{0,i} +$

$$[1 - G(e_i^1 - e_j^1)]F_P^{0,j}\}\, W_P^0 - \{[1 - G(e_i^1 - e_j^1)]F_{NP}^{0,i} + G(e_i^1 - e_j^1)F_{NP}^{0,j}\}W_{NP}^0\} = 0 \qquad \text{(A3.4)}$$

Using the first order approach, we can set up the utility maximization problem in the following way.

$$\max EU_i \qquad \text{(A3.2)}$$

$$\{W_Y, W_P^k, W_{NP}^k, W_P^0, W_{NP}^0, e_i^1\}$$

$$st.\, E\Pi = 0 \qquad \text{(A3.4)}$$

$$\frac{\partial EU_i}{\partial e_i^1} = 0, \text{ given } W_Y,\, W_P^k, W_{NP}^k, W_P^0, W_{NP}^0, \text{ and } e_j^1 \qquad \text{(A3.3)}$$

Because of the symmetry between e_i^1 and e_j^1, the utility function in (A3.2) can be rewritten as (A3.5).

$$EU_i = W_Y + \frac{\delta}{4a}({x_P^k}^2 + {x_{NP}^k}^2) + \frac{1-\delta}{4a}({x_P^0}^2 + {x_{NP}^0}^2) - C(e_i^1) \qquad \text{(A3.5)}$$

The first order condition in (A3.3) can be expressed as (A3.6).

$$g(0)[\delta\left({x_P^k}^2 - {x_{NP}^k}^2\right) + (1 - \delta)\left({x_P^0}^2 - {x_{NP}^0}^2\right)] = 2aC'(e_i^1) \qquad \text{(A3.6)}$$

Lastly, because of the symmetry of the effort choices of the two workers in the same tournament, each firm's zero profit condition in (A3.4) can be rewritten as (A3.7).

$$E\Pi = 2b + 2e_1 - 2W_{\mathrm{Y}} - (1 - \delta)[F_P^0 x_P^0 + F_{NP}^0 x_{NP}^0] - \delta\left[F_P^k(x_P^k - \mathrm{k}) + F_{NP}^k(x_{NP}^k - \mathrm{k})\right] = 0 \qquad \text{(A3.7)}$$

We now solve the maximization problem following the same idea in the original extension of the tournament model. To begin, we solve for the equilibrium first period wage W_Y^{**} using the zero profit condition in (A3.7). Specifically,

$$W_Y^{**} = b + e_1 - \frac{1}{2}\{(1 - \delta)[F_P^0 x_P^0 + F_{NP}^0 x_{NP}^0] + \delta\left[F_P^k(x_P^k - \mathrm{k}) + F_{NP}^k(x_{NP}^k - \mathrm{k})\right]\}. \qquad \text{(A3.8)}$$

Next, let $e_1^{**} \equiv \varphi(x_P^0, x_{NP}^0, x_P^k, x_{NP}^k)$ denote the equilibrium first period effort that satisfies the first order condition in (A3.6). Also, define D as $D \equiv C'^{-1}$. We know from the assumptions on the disutility of effort that $D' > 0$. Thus the equilibrium solution to e_1 satisfies (A3.9).

$$e_1^{**} \equiv \varphi(x_P^0, x_{NP}^0, x_P^k, x_{NP}^k) = \mathrm{D}\{\frac{1}{2a} g(0)[\delta\left({x_P^k}^2 - {x_{NP}^k}^2\right) + (1-\delta)\left({x_P^0}^2 - {x_{NP}^0}^2\right)]\} \qquad \text{(A3.9)}$$

Define $\varphi_l^r \equiv \frac{\partial \varphi}{\partial x_l^r}$, where $l \in \{P, NP\}$ and $r \in \{k, nk\}$, and define D^* as $D^* \equiv \mathrm{D}'\{\frac{1}{2a} g(0)[\delta\left({x_P^k}^2 - {x_{NP}^k}^2\right) + (1-\delta)\left({x_P^0}^2 - {x_{NP}^0}^2\right)]\}$. Taking the derivatives of $\varphi(x_P^0, x_{NP}^0, x_P^k, x_{NP}^k)$ with respect to x_l^r using condition (A3.9) we have (A3.10).

$$\begin{aligned} \varphi_P^k &= \frac{1}{a} D^* g(0) \delta x_P^k \\ \varphi_{NP}^k &= \frac{1}{a} D^* g(0) \delta x_{NP}^k (-1) \\ \varphi_P^0 &= \frac{1}{a} D^* g(0)(1-\delta) x_P^0 \\ \varphi_{NP}^0 &= \frac{1}{a} D^* g(0)(1-\delta) x_{NP}^0 (-1) \end{aligned} \qquad \text{(A3.10)}$$

Define $\rho \equiv 1 - \frac{k}{a}$. Because of the assumption that $0 < k < a$, we know $\rho \in (0,1)$. Now plugging (A3.8) and (A3.9) into (A3.5) and ignoring the constant terms, the maximization problem can be rewritten as (A3.11).

$$\max_{\{x_P^0, x_{NP}^0, x_P^k, x_{NP}^k\}} \varphi\left(x_P^0, x_{NP}^0, x_P^k, x_{NP}^k\right) - \frac{1-\delta}{4}(x_P^0 + x_{NP}^0) - \frac{\delta}{4}\rho(x_P^k + x_{NP}^k) - \mathrm{C}(\varphi(x_P^0, x_{NP}^0, x_P^k, x_{NP}^k)) \qquad \text{(A3.11)}$$

Taking the first order conditions of (A3.11) with respect to the wages yields the following equations.

$$\begin{aligned} (x_P^0)&: \varphi_P^0[1 - C'(e_1^{**})] = \frac{1}{4}(1-\delta) \\ (x_{NP}^0)&: \varphi_{NP}^0[1 - C'(e_1^{**})] = \frac{1}{4}(1-\delta) \\ (x_P^k)&: \varphi_P^k[1 - C'(e_1^{**})] = \frac{\delta}{4}\rho \\ (x_{NP}^k)&: \varphi_{NP}^k[1 - C'(e_1^{**})] = \frac{\delta}{4}\rho \end{aligned} \qquad \text{(A3.12)}$$

Because $0 < \delta < 1$ and $0 < \rho < 1$, we know $\varphi_l^r \neq 0$, where $l \in \{P, NP\}$ and $r \in \{k, 0\}$. In addition, we have $\varphi_P^r = \varphi_{NP}^r$, where $r \in \{k, 0\}$. Therefore, (A3.10) tells us that $x_P^r = -x_{NP}^r$, where $r \in \{k, 0\}$. According to the definitions of x_l^r, we have

$$W_P^r + W_{NP}^r = 2W_m = 2b, r \in \{k, 0\}. \qquad \text{(A3.13)}$$

Restraining our attention to the interior solutions where $e_1^{**} > 0$, it must be the case that $W_P^r > W_{NP}^r, r \in \{k, 0\}$. Therefore, (A3.13) indicates (A3.14).

$$W_P^r > b > W_{NP}^r, r \in \{k, 0\} \qquad \text{(A3.14)}$$

That is, $\varphi_l^r > 0$, where $l \in \{P, NP\}$ and $r \in \{k, 0\}$. This condition further tells us that $C'(e_1^{**}) < 1$, i.e., $e_1^{**} < e_1^S$.

In addition, from (A3.11) we have

$$\frac{\varphi_l^k}{\varphi_l^0} = \frac{\delta x_l^k}{(1-\delta)x_l^0}, \text{ where } l \in \{P, NP\}. \qquad \text{(A3.15)}$$

Because (A3.14) tells us $\frac{\varphi_l^k}{\varphi_l^0} = \frac{\delta}{1-\delta}\rho$, (A3.15) now yields the following relationship.

$$|W_l^k - b| = \rho|W_l^0 - b|, \text{ where } l \in \{P, NP\} \qquad \text{(A3.16)}$$

Therefore, consistent with my previous conjecture, the wage spread under the human capital case is tighter than that under the non-human capital case. The intuition behind this conclusion is that the inefficiencies from turnover for the human capital workers are more costly to firms since these workers are more productive at their current firms, and hence each firm is willing to further sacrifice the ability to elicit effort by offering a tighter wage spread.[98]

Furthermore, due to the conditions in (A3.16), we know (A3.17) holds.

$$W_{NP}^k > W_{NP}^0 \text{ and } W_P^k < W_P^0 \qquad \text{(A3.17)}$$

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[98] Note that the relationship between W_{NP}^k and W_P^0 is ambiguous. It depends on the relationship between the general human capital k and the size of the wage spread $W_P^r - W_{NP}^r$, where $r \in \{k, 0\}$.

That is, workers who are not promoted earn a higher wage if they accumulate human capital while those who are promoted earn a higher wage if they do not accumulate human capital. As a result, the problems of insufficient turnover of the promoted workers and excessive turnover of the non-promoted workers are alleviated compared to the turnover scenarios under the non-human capital case.

(A3.14) and (A3.16) allow us to compare the equilibrium turnover rates to the associated efficient levels of turnover. Recall that P_S^r denotes the efficient turnover rate of a worker with the human capital outcome r. Next, let P_l^r denote the equilibrium turnover rate of a worker with the job assignment l and the human capital outcome r. Because $P_l^r \equiv P(\alpha_i \geq W_l^r - b)$ and that $P_S^0 = P(\alpha_i \geq 0)$, the wage inequalities in (A3.14) indicate that $P_P^0 < P_S^0 < P_{NP}^0$. That is, as in the original extension of the tournament model, there is insufficient turnover among promoted workers and excessive turnover among non-promoted workers if those workers do not accumulate the firm specific human capital. However, because $P_S^k = P(\alpha_i \geq k)$, it is unclear how the turnover rates for the human capital workers compare with the efficient turnover rate. Suppose the human capital is sufficiently small. Then, as is true in the non-human capital case, $P_P^k < P_S^k < P_{NP}^k$. In addition, since $|W_l^k - b| = \rho|W_l^{nk} - b|$, where $l \in \{P, NP\}$, we have $P_P^k > P_P^0$ and $P_{NP}^k < P_{NP}^0$, i.e., given the job assignment, workers with the human capital have a higher turnover rate if they are not promoted and a lower turnover rate if they are. Finally, according to (A3.17), given the job assignment, the human capital wage is different from the non-human capital wage. Because the market wage is independent of the job assignment, given the job assignment, the wage is negatively related to turnover (QED).

APPENDIX 4. FULL SAMPLE AND SUBSAMPLE SUPPLEMENTARY TABLES

Table 13. Logit Estimates for the Impact of Promotion on Labor Turnover, Full Sample

Dependent variable	Turnover(t)			
	(1)	(2)	(3)	(4)
Promotion(t-1)	0.025	0.098	0.071	0.111
	(0.088)	(0.091)	(0.088)	(0.091)
Log-salary(t)	---	-0.676***	---	-0.409**
	---	(0.184)	---	(0.189)
Log-salary(t)-Log-salary(t-1)	---	---	-3.523***	-3.172***
	---	---	(0.636)	(0.651)
Age(t)*100	-6.719	-5.068	-10.358**	-8.966*
	(4.517)	(4.576)	(4.560)	(4.627)
Age(t)^2*10000	3.804	1.841	7.121	5.566
	(5.422)	(5.491)	(5.457)	(5.531)
Education(t)*100	42.142***	42.992***	40.662***	41.292***
	(11.824)	(11.935)	(11.896)	(11.955)
Education(t)^2*10000	-100.095***	-99.884***	-95.221***	-95.489***
	(35.108)	(35.342)	(35.264)	(35.387)
Tenure at company(t-1)*100	-19.298***	-22.496***	-19.498***	-21.430***
	(4.855)	(4.858)	(4.804)	(4.827)
Tenure at company(t-1)^2*10000	70.242***	84.613***	79.536***	87.386***
	(26.809)	(26.767)	(26.623)	(26.625)
Tenure at level(t-1)*100	16.631**	19.386**	13.602*	15.547**
	(7.620)	(7.586)	(7.482)	(7.480)
Tenure at level(t-1)^2*10000	-81.526	-91.667	-65.044	-72.444
	(61.080)	(60.680)	(59.808)	(59.582)
Rating(t-1)	0.313***	0.261***	0.286***	0.257***
	(0.052)	(0.053)	(0.052)	(0.054)
Average turnover rate	0.081	0.081	0.081	0.081
	(0.273)	(0.273)	(0.273)	(0.273)
Level(t-1) indicators	Yes	Yes	Yes	Yes
N	12751	12751	12751	12751
Pseudo R-sq.	0.030	0.032	0.035	0.036
Log likelihood	-3477.833	-3470.437	-3458.288	-3455.771

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; logit coefficients are calculated; job levels are pre-promotion job levels.

Table 14. Estimates for the Impact of Promotion on Labor Turnover, with Promotion-level and Salary-level Interactions, Full Sample

Dependent variable	Turnover(t)							
	OLS				Logit Marginal Effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Promotion(t-1)*level(t-1)=1	0.019*	0.027**	0.020**	0.027**	0.018*	0.026**	0.020**	0.026**
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Promotion(t-1)*level(t-1)=2	0.006	0.012	0.008	0.013	0.006	0.012	0.007	0.012
	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Promotion(t-1)*level(t-1)=3	-0.031**	-0.023*	-0.026**	-0.022	-0.034**	-0.026	-0.029*	-0.026
	(0.012)	(0.014)	(0.012)	(0.014)	(0.015)	(0.016)	(0.015)	(0.016)
Promotion(t-1)*level(t-1)=4	-0.077*	-0.061*	-0.052*	-0.060*	-0.087	-0.086	-0.079	-0.086
	(0.044)	(0.032)	(0.030)	(0.031)	(0.075)	(0.075)	(0.074)	(0.074)
Promotion(t-1)*level(t-1)=5	-0.069*	-0.138**	-0.116***	-0.130**	---	---	---	---
	(0.041)	(0.061)	(0.037)	(0.060)	---	---	---	---
Log-salary(t)*level(t-1)=1	---	-0.074***	---	-0.062**	---	-0.073***	---	-0.061**
	---	(0.024)	---	(0.025)	---	(0.025)	---	(0.026)
Log-salary(t)*level(t-1)=2	---	-0.057**	---	-0.045*	---	-0.054**	---	-0.042
	---	(0.026)	---	(0.026)	---	(0.027)	---	(0.027)
Log-salary(t)*level(t-1)=3	---	-0.059*	---	-0.027	---	-0.055*	---	-0.025
	---	(0.033)	---	(0.034)	---	(0.030)	---	(0.031)
Log-salary(t)*level(t-1)=4	---	-0.013	---	0.018	---	-0.011	---	0.017
	---	(0.029)	---	(0.031)	---	(0.025)	---	(0.025)
Log-salary(t)*level(t-1)=5	---	0.000	---	0.028	---	-0.039	---	0.018
	---	(0.087)	---	(0.083)	---	(0.060)	---	(0.060)
Log-salary(t)*level(t-1)=6	---	-0.191	---	-0.162	---	-0.045	---	-0.267***
	---	(0.200)	---	(0.184)	---	(0.055)	---	(0.059)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=1	---	---	-0.198**	-0.144*	---	---	---	-0.139
	---	---	(0.082)	(0.087)	---	---	---	(0.092)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=2	---	---	-0.176**	-0.145	---	---	---	-0.145
	---	---	(0.089)	(0.091)	---	---	---	(0.094)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=3	---	---	-0.312***	-0.291***	---	---	---	-0.313***
	---	---	(0.080)	(0.082)	---	---	---	(0.089)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=4	---	---	-0.330***	-0.348***	---	---	---	-0.328***
	---	---	(0.097)	(0.099)	---	---	---	(0.099)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=5	---	---	-0.493	-0.524*	---	---	---	-0.570
	---	---	(0.306)	(0.297)	---	---	---	(0.365)
[Log-salary(t)-Log-salary(t-1)] *level(t-1)=6	---	---	-0.550	-0.250	---	---	---	-59.542***
	---	---	(0.556)	(0.292)	---	---	---	(3.253)

Table 14 (Continued)

N	12751	12751	12751	12751	12749	12749	12749	12749

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; all regressions also control for age, education, tenure and the associated square terms, level indicators, and performance ratings; average marginal effects are calculated; adjusted R-square is calculated for the OLS estimates while pseudo R-square is calculated for the logit marginal effects; average turnover rate is 0.081; interaction terms of higher job levels are dropped due to missing data.

Table 15. Logit Estimates for the Impact of Promotion on Labor Turnover, Level Subsamples

Dependent variable	Turnover(t)							
	High-level Subsample				Low-level Subsample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Promotion(t-1)	-0.421**	-0.387*	-0.382*	-0.391*	0.105	0.214*	0.154	0.233**
	(0.204)	(0.208)	(0.205)	(0.209)	(0.105)	(0.109)	(0.105)	(0.110)
Log-salary(t)	---	-0.270	---	0.076	---	-1.021***	---	-0.825***
	---	(0.270)	---	(0.273)	---	(0.264)	---	(0.274)
Log-salary(t)-Log-salary(t-1)	---	---	-4.088***	-4.155***	---	---	-3.056***	-2.407**
	---	---	(0.905)	(0.914)	---	---	(0.929)	(0.955)
Age(t)*100	13.308*	13.777*	10.226	10.025	-14.497**	-11.998**	-18.711***	-15.773**
	(7.914)	(7.967)	(8.016)	(8.044)	(6.010)	(6.065)	(6.085)	(6.190)
$Age(t)^2*10000$	-18.933**	-19.518**	-16.612*	-16.388*	12.842*	10.022	17.242**	13.997*
	(9.228)	(9.291)	(9.348)	(9.382)	(7.433)	(7.479)	(7.480)	(7.581)
Education(t)*100	35.676**	36.655**	34.199*	33.872*	32.366*	30.308*	30.992*	29.389*
	(17.404)	(17.516)	(17.566)	(17.583)	(16.928)	(17.032)	(16.969)	(17.026)
$Education(t)^2*10000$	-92.864*	-94.668*	-87.638*	-86.965*	-58.463	-47.766	-54.289	-45.822
	(50.119)	(50.323)	(50.439)	(50.437)	(51.631)	(51.750)	(51.697)	(51.734)
Tenure at company(t-1)*100	-17.756***	-18.983***	-17.442***	-17.082***	-14.477	-17.689*	-16.214	-18.373*
	(6.029)	(6.128)	(6.011)	(6.128)	(10.160)	(10.057)	(9.997)	(9.946)
Tenure at $company(t-1)^2*10000$	53.891	59.234*	61.946*	60.532*	24.096	36.033	39.400	45.525
	(33.563)	(33.899)	(33.485)	(33.828)	(65.632)	(65.349)	(64.722)	(64.741)
Tenure at level(t-1)*100	30.107***	31.578***	26.902***	26.446***	4.203	5.736	2.191	3.793
	(9.593)	(9.669)	(9.355)	(9.402)	(12.288)	(12.198)	(12.102)	(12.075)
Tenure at $level(t-1)^2*10000$	-215.109***	-220.362***	-194.618**	-192.948**	73.293	66.600	82.706	75.761
	(79.064)	(79.256)	(76.728)	(76.535)	(91.370)	(91.003)	(89.923)	(89.950)
Rating(t-1)	0.377***	0.354***	0.336***	0.342***	0.259***	0.190**	0.245***	0.192***
	(0.074)	(0.077)	(0.075)	(0.077)	(0.073)	(0.074)	(0.073)	(0.074)
Average turnover rate	0.085	0.085	0.085	0.085	0.078	0.078	0.078	0.078
	(0.279)	(0.279)	(0.279)	(0.279)	(0.268)	(0.268)	(0.268)	(0.268)
Level(t-1) indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5644	5644	5644	5644	7107	7107	7107	7107
Pseudo R-sq.	0.030	0.031	0.038	0.038	0.039	0.043	0.043	0.046
Log likelihood	-1590.115	-1589.520	-1577.459	-1577.415	-1866.556	-1858.661	-1859.190	-1854.394

Standard errors in parentheses, clustered by individual; logit coefficients are calculated, * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low-level subsample contains promotions from job levels 1 and 2 while the high-level subsample contains promotions from job levels 3 through 7.

Table 16. Logit Marginal Effects for Promotion, Salary, and Labor Turnover, Point Estimates, Level Subsamples

Dependent variable	Turnover(t)							
	(1)		(2)		(3)		(4)	
	High-level	Low-level	High-level	Low-level	High-level	Low-level	High-level	Low-level
	25th percentile							
Promotion(t-1)	-0.029**	0.005	-0.027*	0.010*	-0.028*	0.007	-0.029*	0.011**
	(0.015)	(0.005)	(0.015)	(0.005)	(0.015)	(0.005)	(0.016)	(0.006)
Log-salary(t)	---	---	-0.019	-0.049***	---	---	0.006	-0.041***
	---	---	(0.019)	(0.014)	---	---	(0.020)	(0.014)
Log-salary(t)-Log-salary(t-1)	---	---	---	---	-0.299***	-0.146***	-0.304***	-0.119**
	---	---	---	---	(0.077)	(0.049)	(0.078)	(0.050)
	50th percentile							
Promotion(t-1)	-0.045**	0.006	-0.041*	0.013*	-0.040*	0.009	-0.041*	0.014**
	(0.022)	(0.006)	(0.022)	(0.007)	(0.021)	(0.006)	(0.022)	(0.007)
Log-salary(t)	---	---	-0.029	-0.063***	---	---	0.008	-0.050***
	---	---	(0.029)	(0.017)	---	---	(0.029)	(0.017)
Log-salary(t)-Log-salary(t-1)	---	---	---	---	-0.427***	-0.182***	-0.434***	-0.145**
	---	---	---	---	(0.095)	(0.056)	(0.097)	(0.058)
	75th percentile							
Promotion(t-1)	-0.039**	0.005	-0.036*	0.010*	-0.033*	0.007	-0.034*	0.011**
	(0.019)	(0.005)	(0.020)	(0.005)	(0.018)	(0.005)	(0.018)	(0.005)
Log-salary(t)	---	---	-0.025	-0.049***	---	---	0.007	-0.037***
	---	---	(0.025)	(0.015)	---	---	(0.023)	(0.014)
Log-salary(t)-Log-salary(t-1)	---	---	---	---	-0.352***	-0.136***	-0.357***	-0.109**
	---	---	---	---	(0.079)	(0.042)	(0.080)	(0.043)
Average turnover rate	0.085	0.078	0.085	0.078	0.085	0.078	0.085	0.078
	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)	(0.279)	(0.268)
N	5644	7107	5644	7107	5644	7107	5644	7107

Standard errors in parentheses, clustered by individual; * significant at 10% level; ** significant at 5% level; *** significant at 1% level; the low-level subsample contains promotions from job levels 1 and 2 while the high-level subsample contains promotions from job levels 3 through 7; average marginal effects are calculated; all regressions also control for age, education, tenure and the associated square terms, as well as level indicators, and performance ratings; all the covariates except for the level indicators are evaluated at the quantiles of the full sample distributions.

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