Internal Promotion Competitions in Firms

Jed DeVaro*
Department of Labor Economics
Cornell University
Ithaca, NY 14853
e-mail: devaro@cornell.edu

July 7, 2003

Abstract

I propose a structural model of promotion tournaments and estimate it on a sample of professional workers in a cross section of firms. I find strong evidence that relative performance of workers, as opposed to absolute performance, determines promotions. However, the data do not support the predictions of tournament theory that worker performance is increasing in the wage spreads from promotions and that firms optimally set wage spreads to induce higher levels of performance. The findings are suggestive of internal promotion competitions and fixed job slots as the average tendency describing promotion decisions in firms.

JEL Classification: M51

* Thanks to Ron Ehrenberg, Martin Farnham, Gary Fields, Bob Hutchens, George Jakubson, Jason Perry, Mike Waldman, and seminar participants at Cornell University for helpful comments. Dana Samuelson provided outstanding research assistance.

1. Introduction

More than two decades ago, the theory of rank-order tournaments as optimum labor contracts was exposited to show that compensation schemes based on workers' ranks within an organization are attractive alternatives to output-contingent contracts, particularly when an employer cannot easily measure a worker's output (Lazear and Rosen 1981). The basic idea of a tournament is that workers of a given rank compete for promotions and that the best worker receives the promotion regardless of this worker's absolute level of performance. That is, to win the promotion you need not perform well. You need only perform better than your competitors. The idea that relative performance rather than absolute performance determines the winner of the promotion tournament is central to the theory, though it is not unique to the theory. By itself, it merely reflects the presence of internal promotion competitions among workers. Tournament theory adds stronger implications arising from the optimizing behavior of workers and firms, in particular that firms optimally set wages to create incentives. Tournament theory has important implications for the compensation structure of the firm and its relation to worker effort and performance. It provides a theory of career advancement and promotions within firms. Despite the appeal of the tournament model, its practical relevance as an explanation for promotions within firms is an empirical question – one that has not been satisfactorily answered.

Confronting the tournament model with data on promotions is difficult because typically available firm-level data lack information on certain key variables. In particular, an analysis of the tournament model requires information on the incentive structure (that is, the prizes awarded to the contestants) and the output or effort levels of the contestants. As Ehrenberg and Bognanno (1990a) note, "The lack of nonexperimental studies of tournaments is probably due to the difficulty of measuring both individuals' effort levels and the incentive structures competitors face in many circumstances." Empirical studies of tournament theory are of two types. One type focuses only on the behavior of workers (or agents), testing to see whether tournaments have incentive effects in that larger prizes imply higher levels of performance. These studies typically use data from sporting events rather than from the context of greatest interest, promotion decisions in real firms. The second type focuses only on the behavior of firms (or principals), testing to see whether prizes appear to be structured to produce incentives in the manner predicted by tournament theory.

In this paper I deviate from previous empirical work by considering the behavior of workers and firms jointly rather than in isolation. I estimate a three-equation structural model, treating worker performance, the firm's wage spread, and promotions as endogenous variables. This is the first study of tournament theory in which the empirical methodology accounts for both the optimizing behavior of workers and firms, and how these behaviors jointly determine promotion outcomes. I estimate the structural model using a cross-sectional employer data set containing information on the wage spread or prize that a worker receives if promoted to the next level, worker performance and relative performance, received and expected promotions, and characteristics of workers and firms. The fact that worker performance measures are observed in a firm-level data set allows a test of the incentive effects of tournaments in the context of greatest interest, promotion decisions in real firms as opposed to sporting events.

A common approach in the area of empirical personnel economics is to study comprehensive data on all of the workers in a single large firm, the identity of which is often undisclosed. In addition to large sample sizes and rich sets of consistently measured variables, the great advantage of such data sets is that there is only one set of firm-specific institutions and procedures operating, rather than a multitude of different processes as is the case in a cross section of firms. Such single firm studies are useful in identifying the empirical regularities that hold simultaneously in one environment. Some influential single-firm empirical studies such as Lazear (1992) and Baker, Gibbs, and Holmstrom (1994a,b) have made important contributions to our understanding of firm behavior. Their advantages notwithstanding, all such studies suffer from a common drawback. Since they are based only on a single firm, there is no way to know how representative that firm's behavior is. Cross sectional studies such as this one provide information that complements that of single-firm studies. In the specific context of tournament theory, rather than testing to see whether aspects of the tournament model hold in a sample of sporting events, or in a single large firm of unknown identity, we ultimately wish to make inferences about the extent to which the model accurately describes the general tendencies of employer behavior across a range of firms. In estimating a structural model using data spread across the full spectrum of firm sizes and types, industries, and distinct geographic labor markets, I hope to shed light on how well the tournament model describes the general tendencies of employer behavior.

When internal hiring policies combine with fixed job hierarchies, the result is a competition among workers for promotions that are based on relative performance, with the highest performer in a particular job rank winning a promotion regardless of this worker's absolute performance level. Throughout this paper I refer to such competitions as *internal promotion competitions*. A tournament takes the idea of an internal promotion competition and adds the further notion that firms optimally choose wage spreads to elicit worker effort. Thus, a promotion tournament is a special case of an internal promotion competition with additional testable implications. Before estimating the structural tournament model, I begin the empirical analysis by asking whether promotions are in fact determined by relative performance as in internal promotion competitions.

The remainder of the paper is organized as follows. I begin by reviewing the literature on tournament theory and describing my data set. I then report empirical analysis in two sections. In the first of these (Section 4), I empirically test the idea that in a cross section of firms, promotions are determined by relative performance as opposed to absolute performance levels. I do in fact find evidence of such internal promotion competitions. In the second of these (Section 5) I attempt to sharpen the picture further by asking whether these internal promotion competitions are well described by the tournament model, which adds stronger predictions that worker performance is increasing in the wage spread from promotions, and that firms set the wage spread to induce optimal worker performance. To address these issues from tournament theory, I estimate a three-equation structural model (worker performance, wage spread, promotions) on a sample of professional workers from the cross section of firms. The structural model illustrates how worker and firm behaviors interact to produce promotions, and I discuss how these joint optimizing behaviors have testable implications that cannot be addressed in the models of the previous literature that focus only on worker behavior or firm behavior individually. I conclude the paper with an interpretation of the collective empirical results.

2. Previous Literature on Tournament Theory

The pioneering work of Lazear and Rosen (1981) showed that tournaments induce the same efficient allocation of resources as output-contingent contracts such as piece-rates and quotas, when the principal and agents are risk neutral. In the model, the firm commits to a fixed wage spread or prize from promotion in advance, before observing worker productivity, with the knowledge that worker effort levels are then chosen optimally given this spread.[1] The basic model has three main

[1] Although virtually all of the literature on tournament theory assumes that the prizes or wage spreads are optimally chosen by firms to induce optimal worker effort levels, a recent exception is Zabojnik and Bernhardt (2001). In their model, wage spreads are determined competitively via a mechanism similar to the promotion signaling process described by Waldman (1984). Given an informational asymmetry in which the current employer knows more about an incumbent worker's ability than do outside employers, promotion of that worker signals to outside employers that the worker is high-ability. Outside employers update their beliefs and bid up the wages of this worker. In my

predictions: 1) worker effort is increasing in the wage spread; 2) worker effort is decreasing in the variance of stochastic determinants of performance; 3) the firm's optimal wage spread is increasing in the variance of stochastic determinants of performance.

Tournament theory was extended further in Holmstrom (1982); Green and Stokey (1983); Nalebuff and Stiglitz (1983); Carmichael (1983); Malcomson (1984); Mookherjee (1984); Rosen (1986); O'Keefe, Viscusi, and Zeckhauser (1986); McLaughlin (1988); Lazear (1989); and Zabojnik and Bernhardt (2001), which address issues such as multiple workers, risk averse workers, heterogeneity in worker ability, multiple periods, collusion and sabotage. Theoretical arguments have been made for and against tournament theory as a model of wage determination and promotion in firms. When workers are risk averse, the case for tournaments over output-contingent contracts is weaker than when workers are risk neutral (Green and Stokey 1983, Nalebuff and Stiglitz 1983, Mookherjee 1984). Furthermore, as in Lazear (1989), tournaments introduce the possibility of collusion and sabotage among workers, reducing the optimal effort supplied. Finally, Baker, Jensen, and Murphy (1988) asked why firms would not simply use wage bonuses to elicit worker effort, relying on promotions only for job assignment, rather than using promotions to accomplish both aims. All of these considerations diminish the attractiveness of tournaments from the firm's perspective. On the other hand, tournaments insure workers against common shocks to output that would adversely impact effort under an output-contingent contract. Perhaps more importantly, tournaments require only that relative worker output be measurable, so in situations where output is costly to measure, output-contingent contracts are precluded and tournaments may be preferable. This would be the case for executives, managers, and many other professional jobs. Given the theoretical arguments for and against the tournament model, the question of how well the model describes promotion decisions in firms must ultimately be answered empirically.

An early experimental study by Bull, Schotter, and Weigelt (1987) found mixed support for the tournament model using a sample of undergraduate paid volunteers from NYU. The empirical literature that followed can be classified into two main branches.

The first addresses only the optimizing behavior of workers (or agents). Representative papers include Ehrenberg and Bognanno (1990a,b), Becker and Huselid (1992), and Knoeber and

---

discussion of tournament theory I take the conventional interpretation that wage spreads are fixed *ex ante* by the employer to induce the optimal level of effort.

Thurman (1994). Studies in this vein ask whether tournaments have incentive effects, focusing on the prediction that effort is increasing in the wage spread or prize. Since these studies do not ask whether spreads are chosen with such effort responses in mind, they merely test whether incentives matter. These studies focus almost exclusively on data from sporting events (golf, bowling, tennis, NASCAR, etcetera) and have the same basic methodology.[2] A performance measure is regressed on some measure of the spread, or prize, interpreting a positive coefficient on the spread as evidence that tournaments have incentive effects. The spread is always treated as exogenous in such regressions. Furthermore, although the theory pertains to worker effort, nonexperimental data on effort is virtually nonexistent, so all of the papers in this literature except Bull, Schotter, and Weigelt (1987) use measures of performance or output rather than effort. Conclusions from this strand of literature generally support the prediction of tournament theory that performance is increasing in the compensation spread rather than in compensation levels.

The second addresses only the optimizing behavior of firms (or principals). Representative papers include O'Reilly, Main, and Crystal (1988), Main, O'Reilly, and Wade (1993), Lambert, Larcker, and Weigelt (1993), Eriksson (1999), and Bognanno (2001). Studies in this vein use firm-level data on corporate executives and ask whether firms choose compensation spreads to create incentives as suggested by tournament theory. Dependent variables in these studies are generally compensation spreads between levels of a job hierarchy. Two predictions of tournament theory are generally tested, both arising from extensions to the basic Lazear and Rosen model. The first is that wage spreads from promotion to a given level should be increasing in the number of workers at the next level down. The reason is that more workers create more competition, which has a negative effect on incentives that the principal counters by setting a larger wage spread. The second prediction, arising from Rosen (1986), is that the compensation structure is convex, meaning that the size of the wage spreads increase with the level of the job. Rosen analyzed an elimination tournament with a fixed job hierarchy and multiple rounds, finding that wage spreads increase with the level of the job because of the diminishing option value of successive promotions.

[2] Knoeber and Thurman (1994) is the only paper in this literature to use data from real firms rather than sporting events, in particular data on producers in the broiler chicken industry who face tournament-style competitions. The authors define an inverse measure of performance called "settlement cost", measured as cents per live weight pounds of chicken. They used time period dummies representing different payment regimes to reflect the use of tournaments. Absent a measure of the spread in their data, they could not establish that larger spreads have positive incentive effects. However, they showed that changes in prize levels alone have no effect on performance.

This second strand of literature finds mixed support for the tournament model. O'Reilly, Main, and Crystal (1988) found that the number of vice presidents was negatively associated with the compensation spread between CEOs and vice presidents. In contrast, Main, O'Reilly, and Wade (1993) found the opposite result in a similar regression. Lambert, Larcker, and Weigelt (1993) used data from four organizational levels (ranging from plant manager to CEO) and found support for the convexity of the pay structure. Using data on Danish executives, Eriksson (1999) found a stable convex relation between compensation and the level of jobs in a hierarchy. He also found that the wage spread is increasing in the number of contestants, as found by Main, O'Reilly, and Wade (1993) using American data. Bognanno (2001) analyzed executives over an eight-year period and found that pay rises strongly with hierarchical level, that most positions are filled through promotions, and that the winner's prize is increasing in the number of contestants though decreasing in the square of the number of contestants. He interpreted the evidence as supportive of the tournament model but noted some conflicting findings.

In this paper I diverge from both branches of previous empirical literature by focusing not on the optimizing behavior of workers or of firms individually, but on both simultaneously. I estimate a structural model with three equations (worker performance, wage spreads, promotions). In contrast to the literature on incentive effects that regresses a measure of performance on a spread that is assumed to be exogenous, I treat this spread as endogenous in the performance equation since it is chosen by the firm to induce optimal worker effort. I describe how the interaction of worker and firm behavior has testable implications for the empirical model that would be missed by focusing only on worker behavior or firm behavior individually. In estimating a model that explicitly accounts for the optimizing behavior of workers and firms, and how the interaction of these behaviors gives rise to promotion decisions, I hope to achieve a somewhat closer marriage of theory and data than has been attained previously. In addition to its methodological departure from the previous literature, to my knowledge this is also the first study to use firm-level data rather than sports data to test directly the prediction that worker performance is increasing in the wage spread.

3. Data: Multi-City Study of Urban Inequality (MCSUI)

The empirical analysis is based on data from the Multi-City Study of Urban Inequality (MCSUI), a cross-sectional employer telephone survey collected between 1992 and 1995. There are 3510 observations in the data and the sampling universe consists of four metropolitan areas:

Atlanta, Boston, Detroit, and Los Angeles. The survey respondent was the owner in 14.5% of the cases, the manager or supervisor in 42%, a personnel department official in 31.5%, and someone else in 12%. Two thirds of the cases come from a probability sample stratified by establishment size (25% 1-19 employees, 50% 20-99 employees, 25% 100 or more employees), drawn from regional employment directories provided by Survey Sampling, Inc. (SSI), primarily based on local telephone directories. The remaining third was drawn from the current or most recent employer reported by respondents in the corresponding MCSUI household survey. Screening identified a respondent who actually carried out hiring for the relevant position, and the survey instrument took 30-45 minutes to administer on the telephone, with an overall response rate of 67%. Sampling weights were constructed to correct for the complexities of the sampling scheme and weighted observations are a representative sample of firms, such as would occur if a random sample of employed people were drawn from each city. For more information about the data, see Holzer (1996).

A substantial fraction of survey questions ask about the most recently hired worker, and these questions form the basis for the empirical analysis. The key variables include this worker's employer-reported subjective performance rating, the employer-reported subjective performance rating for the "typical" worker in that same job, whether the worker was promoted or was expected to be promoted within the next several years, the worker's wages before and after promotion, and the worker's tenure with the firm. Finally, the data contain characteristics of the firm, of the job, and of workers. Summary statistics for the variables used in the empirical analysis of the following section are displayed in Table 1.

4. Are Promotions Determined by Relative, Rather than Absolute, Performance?

The combination of internal hiring policies and fixed job slots creates internal promotion competitions in which promotions depend on the relative performance of workers. It must be emphasized that internal hiring alone does not imply that relative performance determines promotions. In some cases there are not fixed job hierarchies creating internal competitions for a limited, fixed number of promotions. Instead, everyone can, in principle, be promoted for good performance. This is the model used in some consulting firms, in banks, and in research departments in the Federal Reserve System, where workers have job titles like "research associate", "senior research associate", "vice president", and "senior vice president", and often job tasks vary little if at all between levels of the hierarchy. Since there is not a fixed number of vice president positions, the fact that one worker gets promoted to vice president does not adversely affect the probability that another will also be promoted. In such cases, even if all positions are filled with internal candidates, there are not internal competitions and therefore promotions do not depend on relative performance but rather on absolute performance levels of workers. Given the existence of both types of promotion processes, whether the average tendency of firms is to promote based on relative performance or on absolute performance is an empirical question that must be answered using data on a cross section of firms.

The MCSUI data include measures of both observed and expected promotions. The survey asks whether the most recently hired worker has been promoted since the hiring date and, whether or not a promotion has occurred, if one is expected within the next five years. Since the observations are a sample of recent hires, however, in most cases a promotion did not occur by the time of the survey date. Only 266 promotions occurred, which is about 8.4% of the respondents who answered the question definitively. Roughly two thirds of the employers reported expecting the worker to be promoted within five years. The observed variables are defined as follows:

PROMOTE = 1 if a promotion occurred
= 0 if it did not

PROMEXP = 1 if a promotion is expected to occur within the next five years
= 0 if it is not

The performance measure is given by the employer's answer to the following question about the most recently hired worker's performance in the job into which he was hired:

"On a scale of 0-100 where 50 is average and 100 is the best score, how would you rate this employee's performance in this job?"

We also require some proxy for the performance of the most recently hired worker's competitors for promotion. This is provided by another performance measure given by the employer's answer to the following question:

"On a scale of 0-100, how would you rate the typical employee's performance in this job?"

In Table 2 I report results from probit estimation using both promotions and expected promotions as dependent variables. Independent variables include the performance of the most recently hired worker and the performance of the typical worker in that same position. For both dependent variables I also report specifications that control for worker and firm characteristics. If promotions are determined by relative performance in the cross section, then the effect of "own performance" should be positive and the effect of "typical performance" should be negative. That is, if the most recently hired worker is thought to be in competition with other workers at the same level, then holding constant the performance of the competition, an increase in the most recently hired worker's performance should increase the probability that this worker will be promoted. Similarly, holding this worker's performance constant, an increase in the performance level of the competition should decrease the worker's promotion probability.

In fact, this is what is observed in the data, as seen in the first and third columns of Table 2.[3] Both coefficients have the expected signs and are statistically significant at the 2% level, both for promotions and for expected promotions. The reported statistics are probability derivatives for one-unit changes in the performance variables, evaluated at the means. A ten-point increase in the most recently hired worker's performance from the mean value of 78, holding constant the performance of the typical worker in that same position, raises this worker's probability of promotion by about 2.5%.[4] Similarly, holding this worker's performance constant, an increase from 76 to 86 in the performance of the typical employee in this position lowers the probability that the worker will be promoted by more than 1%. The magnitudes of these effects are larger for expected promotions. A ten-point increase in the performance of the most recent hire raises the probability of an expected promotion by 3.6%, and a ten-point increase in the performance of the typical worker in that position lowers the probability of an expected promotion by 2.7%.

To account for the possibility that this unconditional result simply reflects the omission of certain characteristics of workers or firms that determine promotions and expected promotions, I

[3] Although there are 3510 observations in the employer telephone survey, a number of the variables contain missing values. The performance variables in particular had many missing values. This explains the reported sample sizes in the probits.
[4] A ten point increase in performance is roughly half of the standard deviation of performance (22.5).

report specifications with control variables in columns 2 and 4 of Table 2. Controls for worker characteristics include educational attainment and job tenure, specifically dummy variables for whether the most recent hire has more than a high school degree, whether this worker has a college degree or more, this worker's tenure with the firm in months, and the fraction of high-skilled workers currently employed at the firm. Controls for firm characteristics include firm size, number of sites of operation, the fraction of workers covered by collective bargaining agreements, and dummy variables for whether the firm is for profit, whether it is a franchise, whether it employs any temporary workers, and whether it employs any contract workers.

The unconditional result that promotions and expected promotions depend on relative, as opposed to absolute, performance is upheld even after controlling for worker and firm characteristics. The coefficients on own and typical performance are statistically significant with the expected sign, both for promotions and for expected promotions. A ten point increase in the most recently hired worker's performance raises the probability that this worker received a promotion by 1.9 percent and the probability that this worker is expected to be promoted by 3.9 percent. A ten point decrease in the performance of the typical employee in this position decreases the most recently hired worker's chances of promotion and expected promotion by 0.8 percent and 3.1 percent, respectively.

A number of other effects are statistically significant determinants of received and expected promotions. Whether the most recent hire has at least a college degree has a negative effect on promotion probability, and the fraction of workers that have at least a college degree has a positive effect on the probability of expected promotion. Job tenure is the only statistically significant variable that affects received and expected promotion probabilities in opposite directions, raising the probability of promotion and lowering the probability of expected promotion. Union effects, as measured by the fraction of employees covered by collective bargaining agreements, decrease the probabilities of both received and expected promotions. A number of variables that appear not to affect promotion probabilities have statistically significant positive effects on expected promotion probabilities. These are firm size, number of sites on which the firm operates, and whether or not the firm has any temporary workers. Finally, being a for-profit organization has large, positive, statistically significant effects on both the probability of promotion and of expected promotion. The effect is much larger in the case of expected promotions, being four times the size of the effect for promotions.

In summary, in a cross section of promotion decisions across a wide range of workers and firms, the average tendency is for promotions to be determined by relative rather than simply absolute performance. This is suggestive of internal promotion competitions in firms. As mentioned, the presence of internal promotion competitions, and therefore the prediction that relative performance matters, requires more than simply internal hiring and promotions. It also requires that job slots are fixed in a hierarchy. If the prevailing model were one in which workers who simply perform well are rewarded with promotions, then we would expect to see a positive coefficient on own performance, but there would be no reason to expect a negative coefficient on typical performance, even if all jobs were filled using internal candidates. Some jobs clearly are not characterized by internal promotions competitions, even if many of the vacancies are filled internally. Examples include research departments in the Federal Reserve System, university professors, and workers in a number of consulting firms. Nevertheless, the evidence suggests that the notion of internal promotion competitions provides a better description of the average behavior of firms with respect to their promotion decisions.

One can conceive of a number of alternative mechanisms that could generate an internal promotion competition. If job slots are fixed, one possibility is that firms simply choose internal hiring over external hiring because of informational advantages. Hiring internally saves on the recruitment and screening costs associated with external hiring. Furthermore, incumbent workers might have valuable firm-specific institutional knowledge that justifies filling a position through internal promotion. Alternatively, Waldman (2003) argues that internal promotions may be understood as a rational response on the part of the firm to avoid the time inconsistency problem that arises when promotions are used for both job assignment and incentives.

Alternatively, a firm might elect internal hiring so as to motivate workers by the prospect of a promotion tournament as described by Lazear and Rosen (1981). This idea is developed in Chan (1996), where it is argued that in the context of tournaments, internal promotion policies serve as handicapping mechanisms that preserve incentives for a firm's current workers. An alternative way to maintain incentives in the face of external hiring would be to increase the size of the wage spread, but this creates problems of moral hazard on the part of the employer and also creates problems of sabotage and industrial politics as described by Lazear (1989). A promotion tournament is simply a particular case of an internal promotion competition, taking the idea that relative performance determines promotions and adding stronger implications concerning the structure of compensation in the firm and how this affects worker incentives. In particular, tournament theory predicts that the prizes from promotion are fixed in advance and that employers choose these compensation spreads to induce the optimal level of worker effort. The model further suggests that these wage spreads have incentive effects, so that both workers and firms behave strategically in choosing effort levels and wage spreads. I now test these implications of tournament theory.

5. Structural Estimation of the Tournament Promotion Model

I first sketch the two-player tournament model as introduced in Lazear and Rosen (1981) and state the testable implications that emerge from it.[5] Then I construct an empirical model that accounts for the optimizing behavior of both workers and firms and how these behaviors interact to produce promotion decisions.

A Tournament Model of Promotions

Consider a firm with two identical, risk neutral workers and two jobs, a high-level job and a low-level job. Both workers compete for the high-level job, with this promotion (and its associated higher pay) being awarded to the worker who performs the best as a low-level worker during some observation period. Let the low-level job have a salary of W_L and the high-level job have a salary of W_H, where $W_H > W_L$. Both of these wages are fixed in advance, before the productivity of the workers is observed. The probability, ρ, of winning the promotion depends on performance, P, which depends on the workers' levels of effort, E_i and E_j, as follows:

$$P_i = E_i + \varepsilon_i \qquad (5.1a)$$

$$P_j = E_j + \varepsilon_j \qquad (5.1b)$$

[5] Our attention is restricted to a simple two-person tournament, as exposited in Lazear and Rosen (1981). The basic results of the two-person tournament are generalizable to the case of N contestants. The number of players matters, however, insofar as the probability of winning the tournament for any one player is decreasing in the number of competitors. See McLaughlin (1988) for a derivation of expressions for the optimal prize spread and effort levels in a tournament with N contestants.

where the subscripts *i* and *j* denote the two competing workers and ε_i and ε_j denote the stochastic components of performance over which the workers have no control.[6] These are assumed to have mean zero, variance θ, and are independent across workers.

Expected employer profits are given by:

$$E(\pi) = E_i + E_j - (W_H + W_L).$$

We first consider the workers' labor supply conditions that dictate the chosen levels of effort, E_i and E_j, and then discuss the firm's problem, which is to choose the optimal compensation scheme (W_H and W_L) to maximize profits, accounting for worker labor supply behavior and subject to a zero profit constraint.

The Workers' Problem

Worker *i*'s problem is to choose an effort level, E_i, knowing the prizes, W_H and W_L, and the rules of the game but without communicating or colluding with worker *j*. Since the workers are identical, worker *j*'s problem is the same. The players precommit to a chosen effort level without knowing who the opponent will be at the time all decisions are made; each worker plays against the (anonymous) 'field."

Worker *i* chooses an effort level, E_i, to maximize the following expected utility function:

$$\text{Expected Utility} = W_H\rho + W_L(1-\rho) - C(E_i). \quad (5.2)$$

Here, $C(E_i)$ is the monetary cost of effort level E_i, where $C'(E_i) > 0$ and $C''(E_i) > 0$. Noting that worker *i*'s probability of winning the promotion to the high-level job, ρ, is a function of the effort level chosen, the first-order condition for this worker's problem is:

$$(W_H - W_L)\partial\rho/\partial E_i = C'(E_i). \quad (5.3)$$

[6] The original model exposited by Lazear and Rosen is cast in terms of worker output. In light of the empirical work that follows, I use the closely related concept of worker performance instead. This can be thought of as analogous to output.

The left-hand side is the marginal return to effort, that is, the value of the prize ($W_H - W_L$) multiplied by the marginal increase in the probability of winning the promotion for an increase in effort. The optimal labor supply condition states that the worker chooses the effort level that equates the marginal return of effort to its marginal cost.

The probability, ρ, that worker *i* wins the promotion over worker *j* is the probability that *i*'s performance exceeds *j*'s performance. That is,

$$\rho = \text{Prob}(E_i + \varepsilon_i > E_j + \varepsilon_j) = F(E_i\text{-}E_j) \qquad (5.4)$$

where F is the cumulative distribution function of the random variable ($\varepsilon_j - \varepsilon_i$) and f is the associated density function. We can thus rewrite $\partial\rho/\partial E_i$ as $f(E_i\text{-}E_j)$.[7] Since the workers are identical and therefore choose the same effort level, $f(E_i\text{-}E_j)$ can be rewritten as f(0) and the labor supply condition is then:

$$(W_H - W_L)f(0) = C'(E_i). \qquad (5.5)$$

assuming that the Nash equilibrium exists. Here, f(0), the value of the density function at the mean, is inversely related to θ, the variance of the stochastic determinants of performance.

The optimal labor supply condition and the convexity of the effort cost function give rise to two implications about the optimal effort level. First, the worker's level of effort is increasing in the wage spread ($W_H - W_L$). That is, the larger the prize associated with the promotion the greater effort will be, other things equal. Furthermore, changes in the level of compensation that leave the spread unchanged should not affect effort. Wage levels only influence worker participation, which requires a nonnegative expected wage net of effort costs. Second, the effort level is decreasing in θ, the variance of the stochastic component of performance. Intuitively, when random "luck" factors over which the worker has no control become more important determinants of the

[7] This requires the Nash-Cournot assumptions that each worker takes the other's investment in effort as given since he plays against a market over which he has no influence.

promotion probability ρ, the marginal return to effort declines and the worker's incentives to exert effort are depressed.[8]

The Firm's Problem

The firm's problem is to select a compensation scheme (W_H and W_L) to maximize expected profits given the workers' labor supply behavior. Since the two workers are identical, symmetric equilibrium implies that they choose identical effort levels, $E_i = E_j$, and expected profits are given by:

$$E(\pi) = 2E_i - (W_H + W_L) \tag{5.6}$$

The employer's problem is then to choose W_H and W_L so as to maximize:

$$\begin{aligned} &2E_i - (W_H+W_L) \\ &\text{subject to } (W_H+W_L)/2 = C(E_i). \end{aligned} \tag{5.7}$$

The constraint in this problem guarantees worker participation.

The first-order conditions are:

$$2[1 - C'(E_i)]\partial E_i/\partial W_H = 0 \tag{5.8a}$$

$$2[1 - C'(E_i)]\partial E_i/\partial W_L = 0 \tag{5.8b}$$

We have seen that the optimal labor supply condition (5.5) implies that $\partial E_i/\partial(W_H\text{-}W_L) > 0$, which further implies both $\partial E_i/\partial W_H > 0$ and $\partial E_i/\partial W_L < 0$. These facts in conjunction with (5.8a) and (5.8b) imply $C'(E_i) = 1$; the marginal cost of effort equals the per-unit value of the product.

Finally, substituting $C'(E_i) = 1$ into the optimal labor supply condition gives:

[8] The first of these implications, namely that $\partial E_i/\partial(W_H\text{-}W_L) > 0$, follows immediately from (5.5) and the fact that $C'(E_i)$ is monotonically increasing in E_i. To see the second implication, namely that $\partial E_i/\partial f(0) < 0$, note that f(0) is simply the value of the density function evaluated at $E_i\text{-}E_j = 0$. When 'luck" disappe ars from the model, so that the distribution of ε_i becomes degenerate, f(0) goes to infinity. Similarly, when the variance of 'luck" is high so that the luck distribution has long tails, f(0) becomes small. If f(0) increases so that the distribution becomes less disperse (luck matters less), the fact that E_i must increase follows immediately from (5.5) and the fact that $C'(E_i)$ is monotonically increasing in E_i.

$$(W_H - W_L) = 1/f(0). \tag{5.9}$$

That is, the optimal wage spread chosen by the employer is increasing in θ, the variance of the stochastic component of performance. Intuitively, as random factors matter more in dictating the probability of winning the promotion, a larger wage spread (or prize) is required to induce the worker to exert a given amount of effort.

Testable Propositions of the Tournament Model

In the empirical work I focus on four testable propositions of the tournament model. The first three are implications that emerge from the model and the fourth is a key underlying assumption. Specifically, they are:

1) worker effort is increasing in the wage spread
2) worker effort is decreasing in the variance of stochastic determinants of performance
3) the wage spread is increasing in the variance of stochastic determinants of performance
4) relative performance, as opposed to absolute performance levels, determines promotions

Given the nature of my data, I address neither the convexity of the compensation structure nor the effect of the number of players on the spread. Instead I focus on the basic ideas from Lazear and Rosen that promotions are determined by relative performance, that tournaments have incentive effects in that worker performance is increasing in the wage spread from promotion, and that wage spreads are chosen optimally by employers in light of the optimal labor supply behavior of workers.

Empirical Model for Estimating the Tournament Promotion Model

Beginning with worker behavior, consider a linear approximation to the labor supply function defined by (5.5) that defines effort as a function of the wage spread. Then substituting performance for effort, using (5.1a), the worker's linearized opt imal performance function can be expressed as follows:

$$P_i = \alpha_0 + \alpha_1 S_i + \mathbf{X}_i \alpha_2 + \varepsilon_{1i} \tag{5.10}$$

where P_i is worker performance, $S_i = (W_H - W_L)$ is the wage spread that the worker receives if promoted, $\mathbf{X}_i$ is a vector of worker characteristics, and ε_{1i} is a disturbance representing the unobserved determinants of performance.

Firm behavior is described by the optimal wage spread equation (5.9), where the wage spread is increasing in θ, the variance of the stochastic component of performance. The optimal wage spread can be expected to vary by firm characteristics. Furthermore, anything observed by the employer that affects worker performance also affects the employer's choice of the spread since the firm chooses the spread to induce the optimal level of performance. That is, anything that appears on the right-hand side of (5.10) and that is observed by the employer also determines the employer's choice of wage spread, whether or not the econometrician observes the variables. A linearized version of the firm's optimal wage spread equation can thus be expressed as follows:

$$S_i = \beta_0 + \mathbf{F}_i\boldsymbol{\beta}_1 + \mathbf{X}_i\boldsymbol{\beta}_2 + \varepsilon_{2i} \qquad (5.11)$$

where $\mathbf{F}_i$ is a vector of firm characteristics, $\mathbf{X}_i$ is the vector of worker characteristics appearing in the performance equation, and ε_{2i} is a disturbance representing unobserved determinants of the wage spread.

Testable Proposition 1 states that α_1, the coefficient on the wage spread in the performance equation (5.10), should be positive. If the performance equation is estimated by OLS, as it has been in the previous literature, a behavioral interpretation cannot be attached to α_1. We cannot say that the estimated α_1 measures the amount by which worker performance increases in response to an increase in the spread, S, unless we assume $\mathrm{Cov}(\varepsilon_{1i},\varepsilon_{2i}) = 0$. This assumption is clearly untenable since both disturbances include common components, most notably θ, the variance in the stochastic component of performance in (5.1a,b). The tournament model predicts that worker performance is decreasing in θ and that the wage spread is increasing in θ. More generally, factors that depress incentives cause the employer to increase the wage spread to counter the depressed incentives. [9] Therefore, $\mathrm{Cov}(\varepsilon_{1i},\varepsilon_{2i}) < 0$ and consistent estimation of α_1 requires a simultaneous

[9] To see this, note that the structural disturbances may be decomposed as follows: $\varepsilon_{1i} = \tau\theta_i + \varepsilon_{1i}^*$ and $\varepsilon_{2i} = \varphi\theta_i + \varepsilon_{2i}^*$, where θ_i is the variance in the stochastic determinants of worker *i*'s performance, τ and φ are parameters, and ε_{1i}^* and ε_{2i}^* are disturbances that are assumed uncorrelated with θ_i. Hence, $\sigma_{12} = \mathrm{cov}(\varepsilon_{1i}, \varepsilon_{2i}) = \tau\varphi\mathrm{Var}(\theta_i) + \mathrm{cov}(\varepsilon_{1i}^*, \varepsilon_{2i}^*)$. The

equations estimation approach. Furthermore, since $Cov(\varepsilon_{1i},\varepsilon_{2i})$ is an estimable parameter (namely σ_{12} in the covariance matrix Σ), we can readily test the Testable Propositions 2 and 3. Together, they imply $\sigma_{12} < 0$.

It remains to show how the optimizing behaviors of workers and firms, represented by Equations (5.10) and (5.11), interact to produce promotions. Consider a latent index, $PROM^*$, that can be interpreted as a performance threshold for the most recently hired worker that, if exceeded, results in this worker's promotion. The observed dichotomous promotion variable is defined as follows:

$$PROM_i = 1 \text{ if } P_i > PROM_i^*$$
$$= 0 \text{ if } P_i \leq PROM_i^*.$$

I refer to the latent threshold $PROM^*$ as the 'bar". It depends on both firm and worker characteristics, and on the performance of the other workers competing with the most recently hired worker for the promotion. A linear specification of the latent promotion threshold is as follows:

$$PROM_i^* = \gamma_0 + \mathbf{F}_i\gamma_1 + \mathbf{X}_i\gamma_2 + \gamma_3 P_0 + \varepsilon_{3i} \qquad (5.12)$$

where $\mathbf{F}_i$ is a vector of firm characteristics, $\mathbf{X}_i$ is a vector of worker characteristics, P_0 is the performance of the competitors the most recently hired worker faces in the quest for promotion, and ε_{3i} is a disturbance. The theory predicts that γ_3 should be positive (Testable Proposition 4), since the higher the performance of the worker's competition, the higher the bar and therefore the lower the probability of promotion. This simply says that promotions are determined by relative performance.

optimal labor supply condition (5.5) implies $\tau < 0$ and the firm's optimal wage spread equation (5.9) implies $\varphi > 0$, so the term $\tau\varphi Var(\theta_i)$ is negative. Furthermore, $cov(\varepsilon_{1i}^*, \varepsilon_{2i}^*)$ should also be negative since factors that depress worker effort and thereby performance also induce the firm, other things equal, to increase the wage spread to compensate. An example of such a factor is the number of players in the tournament, N_i. Although the theoretical model assumes a two-player game to simplify the exposition, the main results generalize to a tournament with N players with $\partial P_i/\partial N_i < 0$ and $\partial S_i/\partial N_i > 0$. To the extent that the structural disturbances include factors like N_i the prediction that $\sigma_{12} < 0$ is strengthened.

For the purpose of specifying the empirical model, it is convenient to define a second latent index, $I^* = P_i - PROM_i^*$, interpretable as the amount by which the most recently hired worker's performance exceeds the bar. This amount can be either positive or negative, so

$Prob[PROM_i = 1] = Prob[I^* > 0]$ and $Prob[PROM_i = 0] = Prob[I^* \leq 0]$.

Substituting equation (5.11) into equation (5.10), and then substituting both the resulting reduced form performance equation and (5.12) into the equation for I^*, we can write this latent index as:

$$I^* = \lambda_0 + \mathbf{F}_i\boldsymbol{\lambda}_1 + \mathbf{X}_i\boldsymbol{\lambda}_2 + \lambda_3 P_0 + \nu_i \qquad (5.13)$$

where $\lambda_0 = (\alpha_0+\alpha_1\beta_0-\gamma_0)$, $\boldsymbol{\lambda}_1 = (\alpha_1\boldsymbol{\beta}_1-\boldsymbol{\gamma}_1)$, $\boldsymbol{\lambda}_2 = (\alpha_1\boldsymbol{\beta}_2+\boldsymbol{\alpha}_2-\boldsymbol{\gamma}_2)$, $\lambda_3 = -\gamma_3$, and $\nu_i = \varepsilon_{1i}+\alpha_1\varepsilon_{2i}-\varepsilon_{3i}$.

The system of equations to be estimated is then:

$$P_i = \alpha_0 + \alpha_1 S_i + \mathbf{X}_i\boldsymbol{\alpha}_2 + \varepsilon_{1i} \qquad (5.14a)$$

$$S_i = \beta_0 + \mathbf{F}_i\boldsymbol{\beta}_1 + \mathbf{X}_i\boldsymbol{\beta}_2 + \varepsilon_{2i} \qquad (5.14b)$$

$$I_i^* = \lambda_0 + \mathbf{F}_i\boldsymbol{\lambda}_1 + \mathbf{X}_i\boldsymbol{\lambda}_2 + \lambda_3 P_0 + \nu_i \qquad (5.14c)$$

$$PROM_i = \begin{cases} 1 & \text{if } I_i^* \geq 0 \\ 0 & \text{otherwise} \end{cases} \qquad (5.14d)$$

Given estimates of the parameters in this system, the γ parameters of equation (5.12) can then be found by applying the relations following equation (5.13).

I make the conventional distributional assumption in models of this type that $(\varepsilon_{1i},\varepsilon_{2i}, \nu_i)$ is i.i.d. multivariate normal with mean vector zero and covariance matrix $\boldsymbol{\Sigma}$. Let f denote the joint density function and F the cumulative distribution function.[10] The next step is to define the terms $f(P_i,S_i|PROM_i = 1)$ and $f(P_i,S_i|PROM_i = 0)$ that appear in the two branches of the likelihood function, corresponding to the two possible values of $PROM_i$. Defining $K_i \equiv \lambda_0 + \mathbf{F}_i\boldsymbol{\lambda}_1 + \mathbf{X}_i\boldsymbol{\lambda}_2 + \lambda_3 P_0$, we can write the first of these terms as follows:

[10] To avoid a proliferation of notation in deriving the likelihood function, I use f and F generically to denote densities and cumulative distribution functions.

$f(P_i,S_i|PROM_i = 1) = f(P_i,S_i|\ I_i^* > 0]) = f(\varepsilon_{1i},\varepsilon_{2i}\ |\ \nu_i > -K_i) \times \mathbf{J} =$

$$\int_{-K_i}^{\infty} f(\varepsilon_{1i},\varepsilon_{2i},\nu_i)d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 1) =$$

$$\int_{-K_i}^{\infty} f(\nu_i\ |\ \varepsilon_{1i},\varepsilon_{2i})f(\varepsilon_{1i},\varepsilon_{2i})d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 1) =$$

$$f(\varepsilon_{1i},\varepsilon_{2i}) \int_{-K_i}^{\infty} f(\nu_i\ |\ \varepsilon_{1i},\varepsilon_{2i})d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 1) =$$

$$f(\varepsilon_{1i},\varepsilon_{2i})\Phi(\frac{K_i - \mu}{\sigma}) \Big/ \Pr ob(PROM_i = 1)$$

where $\mathbf{J}$, the Jacobian of transformation from $(\varepsilon_{1i},\varepsilon_{2i},\nu_i)$ to (P_i,S_i,I_i^*), is equal to 1, $f(\varepsilon_{1i},\varepsilon_{2i})$ is a bivariate normal density function, Φ denotes the standard normal cdf, and μ and σ denote the mean and standard deviation of the conditional distribution of ν_i given ε_{1i} and ε_{2i}.

Similarly, the second of these terms is:

$f(P_i,S_i|PROM_i = 0) = f(P_i,S_i|\ I_i^* \le 0]) = f(\varepsilon_{1i},\varepsilon_{2i}\ |\ \nu_i \le -K_i) \times \mathbf{J} =$

$$\int_{-\infty}^{-K_i} f(\varepsilon_{1i},\varepsilon_{2i},\nu_i)d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 0) =$$

$$\int_{-\infty}^{-K_i} f(\nu_i\ |\ \varepsilon_{1i},\varepsilon_{2i})f(\varepsilon_{1i},\varepsilon_{2i})d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 0) =$$

$$f(\varepsilon_{1i},\varepsilon_{2i}) \int_{-\infty}^{-K_i} f(\nu_i\ |\ \varepsilon_{1i},\varepsilon_{2i})d\nu_i \times \mathbf{J} \Big/ \Pr ob(PROM_i = 0) =$$

$$f(\varepsilon_{1i},\varepsilon_{2i})\left[1 - \Phi(\frac{K_i - \mu}{\sigma})\right] \Big/ \Pr ob(PROM_i = 0).$$

The likelihood function, L, is then given by:

$$L = \prod_{i=1}^{N} [f(P_i,S_i|PROM_i = 1)Prob(PROM_i = 1)]^{PROM\,i} [f(P_i,S_i|PROM_i = 0)Prob(PROM_i = 0)])^{(1-PROM\,i)}$$

The usual rank conditions for identification hold in this model unless all elements of β_1 are equal to zero. Therefore, it is the exclusion of firm characteristics from (5.14a) that identifies the performance equation. This identifying assumption can be justified on the grounds that employers know more about the firm than recently hired workers do, so workers are less able to assimilate information about firm characteristics into a decision function than firms are worker characteristics. This is especially so given that the typical recently hired worker has experience with only a small number of previous employers, if any at all, whereas the firm represents a wealth of historical information about how certain worker-types perform in given positions. With this exclusion restriction, all of the parameters in (5.14a) and (5.14b) are identified. Those in (5.14c) are identified only up to a scalar multiple since only the discrete realization of the endogenous promotion variable is observed and not its latent index. The three parameters in the covariance matrix Σ that are associated with this equation are also identified only up to a scalar multiple. The usual identifying normalization $\sigma_{\nu\nu} = 1$ is therefore assumed, and otherwise Σ is unrestricted.

Definitions of Variables

Measures of worker performance, P_i, and the performance of the competition, P_0, are defined in the previous section, as are the worker characteristics, $\mathbf{X}_i$, and the firm characteristics, $\mathbf{F}_i$. The wage spread, S_i, is the prize that a worker wins in the event of a promotion. This spread may be thought of as the difference in the present discounted values of total compensation between the two positions, including such nonpecuniary factors as the prestige of the higher-level job, the benefits of a larger office, etcetera. The empirical proxy I use for this spread is the difference in hourly wages between the two jobs. Since the sample consists of recently hired workers, more than 90% of them have not yet been promoted by the survey date. For these workers, S_i is defined as the difference between the wage they will receive if they get promoted and their current wage. For the remaining workers who have already received a promotion, the spread is defined as the difference between their current (post-promotion) wage and their starting wage, since this is the spread that is relevant for determining their performance level in the job into which they were hired.

More precisely, the questions pertaining to the wages of the most recently hired worker are:

W_0 = "What is [this employee's] actual starting wage/salary?"

W_1 = "If promoted, what would this employee's wage or salary be?"

W_2 = "What is his/her current wage/salary?"

The reported time frame for these wages was either hourly, weekly, monthly, or annually, and I converted all responses to hourly wages measured in 1990 dollars, deflated using the CPI-UX. From these I define the wage spread, S:

$S_i = W_{1i} - W_{2i}$ if worker i has not yet been promoted by the survey date
$= W_{2i} - W_{0i}$ if worker i has been promoted by the survey date

In the interests of preserving sample observations, I combined the two promotion variables to produce one dependent variable for promotion that is defined for all observations in the sample, whether or not the worker received a promotion by the survey date. That is:

PROM = 1 if either PROMOTE = 1 or PROMEXP = 1
= 0 otherwise.

This variable is an indicator for whether a promotion has been received or is expected for the most recently hired worker. An alternative approach would be to restrict the sample to those observations for which a promotion was not yet observed by the survey date. In that case, S_i would be $W_{1i} - W_{2i}$ for all observations, and the promotion variable would be PROMEXP for all observations. I estimated the model using both the pooled sample and using only data on expected promotions and found that the results were relatively insensitive to pooling the observations in this way. So my preference is for the pooled results and I report only these. Summary statistics for all variables in the structural model are presented in Table 3, for the subsample of workers in professional occupations.

The omission of wage levels, as opposed to the wage spread, from the right-hand side of the performance equation (5.14a) requires some comment. The tournament model predicts that worker performance is an increasing function of wage spreads rather than wage levels, although wage levels affect a worker's participation decision regarding whether to w ork for the firm. That is, an increase in the spread, holding the average wage levels constant, induces higher performance. This suggests that a test of the effect of the wage spread on performance necessitates controlling for wage levels. By estimating the structural model only on a subsample of professional occupations, I roughly control for wage levels by considering a relatively homogeneous group of workers with respect to skill level. Nevertheless, I also estimated the structural model including a measure of wage levels (in particular the average of the pre and post-promotion wages) on the right-hand side of the performance equation. The coefficient on average wages was statistically insignificant and near zero. Since the other coefficients in that specification remained substantively unchanged, I only report results based on the specification that omits wage levels.

Apart from the issue of controlling for wage levels, there is another argument for restricting the sample to professional workers. The conventional wisdom is that promotion tournaments are more likely to occur in higher-skilled management jobs than in low-skilled jobs. The reason is that output is typically easier to measure for low-skilled workers than for managers, so output-contingent compensation schemes like piece rates that might be used for motivating low-skilled workers are not effective for motivating skilled managers. Tournaments, on the other hand, induce effort with only the requirement that relative output be measurable. Estimating the structural model on a sample of professional workers in effect gives the tournament model its 'best chance." In the MCSUI survey, employers were asked about the job into which the most recent worker was hired, and responses were recorded according to the 1980 SOC codes. I used these to construct a subsample of professional workers with 520 observations. Missing values in a number of the variables in the model reduce the usable sample size to 215 observations. According to the 1980 SOC codes these workers include administrative, engineering, scientific, teaching, and related occupations, including creative artists.

6. Estimates from the Structural Tournament Model

Recall that there are four testable propositions that have the following implications for the parameter estimates:

Testable Proposition 1: $\alpha_1 > 0$

Testable Propositions 2 and 3: $\sigma_{12} < 0$

Testable Proposition 4: $\gamma_3 > 0$

Maximum likelihood estimates of the 36 parameters from the structural model are reported in Table 4, with asymptotic standard errors in parentheses below each estimate. The upper panel contains estimates of the slope coefficients from the P, S, and PROM* equations (5.14a, 5.14b, and 5.12, respectively) and the lower panel contains estimates of the five covariance parameters. The γ coefficients from the PROM* equation, reported in the third column of Table 4, are computed using the relations following equation (5.13). Some of the variables were rescaled to facilitate estimation, and one should recognize this when interpreting the magnitudes of the estimates. In particular, both performance variables were rescaled by dividing by 100 to produce an index from zero to one. The wage spread was divided by ten, so a spread of 0.2 actually represents a spread of two dollars per hour. Job tenure is measured in years, so a tenure of 1.75 means the worker has been with the firm for one year and nine months. Finally, firm size is measured in thousands of workers.

The key underlying assumption of the tournament model that relative performance determines promotions is clearly upheld by the data. The estimate of γ_3, the coefficient of P_0 in equation (5.12) is positive and statistically significant at the 5% level, as required by the theory, with a value of 1.63. Furthermore, this effect is the most statistically and economically significant effect in the promotion equation. This result implies that relative performance matters in the sense that a higher level of performance of the competition increases the ‘bar” and ther eby reduces the promotion probability for the most recently hired worker. Keeping in mind the 100-point performance scale, a ten-point increase of the performance of the most recently hired worker’s competitors implies more than a 16-point increase in the promotion bar.

The prediction that $\alpha_1 > 0$ is not upheld by the data, since the estimated coefficient of the wage spread in the performance equation is –0.222, statistically insignificant at conventional levels, suggesting that higher wage spreads from promotions do not induce higher worker performance. The prediction that $\sigma_{12} < 0$, is also not upheld by the data, since the estimate is positive, though statistically insignificant, with a value of 0.046. This result suggests that performance levels and spreads are not strategically chosen by workers and firms in the manner suggested by tournament theory.

Although two of the predicted effects are not supported by the data, a cautious interpretation is required in a cross section of promotion decisions across a wide range of firms, some of which may be engaging in promotion tournaments and some of which may not. It is quite plausible that some fraction of the firms in the sample are engaged in promotion tournaments which indeed have incentive effects so that $\alpha_1 > 0$,[11] while for other firms operating under a different model $\alpha_1 < 0$, so that the average effect in the cross section is statistically indistinguishable from zero. A potential explanation for a negative sign on α_1 is that in such firms a component of compensation is in fact based on observed ability rather than pre-determined as in the tournament model. Then within a tier of the promotional hierarchy, higher-ability workers are paid more than other workers in that tier, *ceteris paribus*. When the employer is asked, *"If promoted, what would this employee's wage or salary be?"* in some cases the employer might respond with the midpoint of the range for the next tier up in the promotional hierarchy. This would produce a higher wage-spread for lower-ability workers than for higher-ability workers.

Further caution in interpreting the rejection of $\alpha_1 > 0$ as evidence against the tournament model is warranted to the extent that S_i, the increase in hourly wages resulting from a promotion, is too crude a proxy for the change in total compensation accompanying a promotion. The relevant measure of the "wage spread" should include not only the present discounted value of wages and fringe benefits, but all other nonpecuniary benefits that accompany promotions, such as increased prestige, larger offices, etcetera. A multitude of factors determine the worker's difference in utility between positions on a promotional hierarchy, and that is the relevant "spread" for providing incentives to workers. Nevertheless, if the measured S_i may be considered a reasonable proxy for the relevant promotion spread, then the joint rejections of $\alpha_1 > 0$ and $\sigma_{12} < 0$ indicate that larger spreads do not induce higher levels of worker effort and performance, and that firms are not choosing promotion wage spreads so as to induce higher performance. If firms were choosing such spreads in the way suggested by tournament theory, then we would expect to see $\sigma_{12} < 0$.

Apart from the theoretically relevant results concerning the parameters γ_3, α_1, and σ_{12}, the effects of some of the worker and firm characteristics on performance, wage spreads, and the promotion threshold are worthy of mention. In the performance equation, the fraction of high-skilled workers has a statistically significant and positive effect on the performance of the most recently hired worker, though the effect is small in magnitude. A 10% increase in the fraction of

[11] It must be mentioned that this prediction is not unique to the tournament model. An alternative interpretation is that performance does not respond to a wage spread fixed in advance but rather that the wage spread (and promotion) is awarded by the employer *ex post* after the ability of the worker is revealed over time, as argued in Gibbons and Waldman (1999) and other studies.

high-skilled employees at the firm implies less than a two point increase in worker performance on the 100-point scale. In the wage spread equation, the only statistically significant effects at conventional levels are job tenure and the fraction of workers covered by collective bargaining agreements. Both effects are positive. An extra year of job tenure increases the wage spread by about 75 cents, and a ten percent increase in the fraction of workers covered by collective bargaining agreements implies an increase in the wage spread of about twenty cents per hour.

In the latent promotion threshold equation, the educational attainment of the most recently hired worker and the skill composition of the current workforce do not have statistically significant effects on promotion probability. Job tenure increases the performance "bar" for promotion, thereby reducing the promotion probability. This effect is statistically significant, and mirrors the result seen in the fourth column of Table 2 for the full sample of workers in all occupational groups. Two firm characteristics also have statistically significant effects on the promotion threshold. Being employed at a for-profit firm significantly decreases the promotion "bar" by about 38 "performance points" on the 100 -point scale. The fraction of current workers covered by collective bargaining agreements increases the promotion "bar", thereby decreasing promotion probability. A ten percent increase in the fraction of covered workers increases the promotion bar by about five performance points on the 100-point scale.

In summary, the evidence from the structural estimation of the tournament model is that in a cross section of firms promotions of professional workers are determined by relative performance as opposed to simply absolute levels of performance. This is a central idea from the theory of promotion tournaments, though it is not unique to the tournament model. The prediction that promotion wage spreads have incentive effects in inducing higher levels of effort and performance is not supported in the data, nor is the prediction that increases in the variance of the stochastic component of worker performance decrease performance and increase the firm's chosen wage spread. An interpretation of these collective findings is that, across a wide range of firms spanning all industries in metropolitan labor markets, internal competitions describe promotions of professional workers, though it appears that the view that firms optimally fix wage spreads *ex ante* to induce higher levels of worker performance, at least in the manner suggested by the simple static model, is not a good description of the average tendency of firms.

7. Concluding Remarks

The evidence clearly shows that relative worker performance determines promotion decisions in a cross section of firms. This is true both unconditionally, and controlling for worker and firm characteristics. This suggests that internal promotion policies and fixed job slots combine to create internal promotion competitions in many firms. After establishing this in the data, I endeavored to sharpen the picture further by empirically testing the proposition that these internal competitions are well described as promotion tournaments of the type discussed in Lazear and Rosen (1981). I constructed a structural model of promotion tournaments, treating worker performance, wage spreads, and promotion decisions as jointly endogenous, and estimated the model on a sample of professional workers across the cross section of firms. This structural approach distinguishes the present paper from the preceding empirical literature on tournament theory and provides a framework for future tests of the tournament model using more extensive cross sections or panels of firms. The structural estimates do not support the predictions of tournament theory that worker performance is increasing in the wage spread from promotions, and that firms optimally choose wage spreads to induce higher levels of performance. However, strong support is found again for the notion that promotions of professional workers are determined by relative performance.

Although the collective results are subject to alternative interpretations, I will offer one that I believe merits closer scrutiny in future work. I have argued that it is the combination of internal promotion decisions and fixed job slots that creates the internal promotion competitions that appear to describe average behavior in the cross section. The fixity of the job slots and the nature of tasks performed in each job is in many cases dictated by the production process and is therefore beyond the control of the decision-making entities of firms. That is, there are only some jobs, such as those in research, in which "everyone can be a vice president". In many other jobs there can only be one boss, and there is a fixed hierarchy with tasks associated at each level, as determined by the production process. Internal versus external hiring and promotions, however, can be thought of as more flexible and more subject to choice on the part of the firm. If a vacancy is created in a job hierarchy with fixed job slots, management can either fill the position with an external candidate or with an incumbent worker. The evidence indicates that a good description of the average tendency is one in which fixed job slots are combined with internal hiring.

This leaves open the question of why firms hire and promote internally. One story is that promotions are used as incentive mechanisms, so the hiring must be from within to preserve worker incentives. This view is discussed by Chan (1996). The argument is that external hiring reduces incentives for current workers. The firm can respond either by increasing the wage spread from promotion, or by using an internal hiring policy as a handicap that favors internal workers. The latter policy avoids the problems of moral hazard and industrial politics that arise from large wage spreads. An alternative view presented by Waldman (2003) is that firms promote internally to avoid the time inconsistency problem arising when promotions are used to achieve both job assignment and incentive creation. That is, a policy of internal hiring allows a firm to credibly commit to the profit-maximizing promotion policy, while in the absence of such commitment the *ex post* optimal strategy for the firm would focus purely on job assignment. This would involve significant outside hiring, and internal incentives would suffer. Yet another motivation for internal hiring could be informational, in the sense that it is cheaper to obtain reliable information about existing workers than about outsiders. Furthermore, incumbent workers possess firm-specific institutional knowledge that can enhance their productivity in the promotion and reduce the costs of "learning the ropes" in the new position. That is, the major informational issue determining an employer's decision between internal and external hiring may be the observability of current worker output over that of prospective outside hires, rather than the unobservability of current worker output as in the tournament model.

Hiring internally when job slots are fixed necessarily creates some incentive effects of promotions, even if employers are not fixing the compensation structure *ex ante* to induce optimal worker performance. If workers know that the promotion is likely to be from within, and there are only a fixed number of slots, this necessarily creates incentives to win the promotion even if compensation is determined *ex post* after the firm observes worker productivity, as in Gibbons and Waldman (1999) and other related work. If a firm can save on information costs by hiring internally, and if such internal hiring creates promotion incentive effects, it is plausible that the firm might sometimes pass up a more qualified outsider in favor of an insider. Finally, this interpretation of internal promotion competitions and the motivation for internal hiring would also be relevant in cases in which wages and wage spreads from promotions are subject to institutional constraints such as collective bargaining agreements, where choice of an optimal compensation structure to induce worker performance as in the tournament model is not even an option.

In summary, fixed job slots characterize many production processes. If combined with internal hiring policies, the result is an internal promotion competition in which relative performance determines promotions. Firms may choose internal promotions over external hiring for a number of reasons, either purposefully to create incentive effects for incumbent workers, to avoid the time inconsistency problem associated with using promotions to achieve both incentives and job assignment, or simply to economize on the informational advantages of hiring incumbent workers with firm-specific human capital over unknown outside candidates. To the extent that promotions are associated with higher wages, more interesting work, better offices, and other nonpecuniary compensation, workers will compete with each other to win these internal promotion competitions no matter what determines these compensation spreads.

References:

Baker, G.P, M.C. Jensen, and K.J. Murphy (1988), "Compensation and incentives: practice vs. theory", *Journal of Finance* 43: 593-616.

Baker, G.P., M. Gibbs, and B. Holmstrom (1994a), "The Internal Economics of the Firm: Evidence from Personnel Data", *Quarterly Journal of Economics* 109: 881-919.

Baker, G.P., M. Gibbs, and B. Holmstrom (1994b), "The Wage Policy of a Firm", *Quarterly Journal of Economics* 109: 921-955.

Becker, B. and M. Huselid (1992), "The Incentive Effects of Tournament Compens ation Systems", *Administrative Science Quarterly* 37: 336-350.

Bognanno, Michael L. "Corporate Tournaments." *Journal of Labor Economics*, volume 19 number 2 (2001).

Bull, Clive, Andrew Schotter, and Keith Weigelt. "Tournaments and Piece Rates: An Experimental Study." *Journal of Political Economy* 95 (February 1987): 1-33.

Carmichael, H. Lorne. "The Agent -Agents Problem: Payment by Relative Output." *Journal of Labor Economics* 1 (January 1983): 50-65.

Chan, William (1996). "External Recruitment versu s Internal Promotion", *Journal of Labor Economics* 14: 555-570.

Ehrenberg, Ronald G., and Michael L. Bognanno. "The Incentive Effects of Tournaments Revisited: Evidence from the European PGA Tour." *Industrial and Labor Relations Review* 43 (February 1990a): 74S-88S.

Ehrenberg, Ronald G., and Michael L. Bognanno. "Do Tournaments Have Incentive Effects?" *Journal of Political Economy* 98(6) (December 1990b): 1307-24.

Eriksson, Tor. (1999) "Executive Compensation and Tournament Theory: Empirical Tests on Danish Data." *Journal of Labor Economics*. Vol 17, No. 2.

Gibbons, Robert, and Michael Waldman. "A Theory of Wage and Promotion Dynamics Inside Firms." *Quarterly Journal of Economics*. (November 1999).

Green, Jerry R. and Nancy L. Stokey. "A Comparison of Tournaments and Contracts." *Journal of Political Economy* 91 (June 1983): 349-64.

Holmstrom, Bengt. "Moral Hazard in Teams." *Bell Journal of Economics* 13 (Autumn 1982): 324-40.

Holzer, Harry. *What Employer Want: Job Prospects for Less-Educated Workers*. New York: Russell Sage Foundation, 1996.

Knoeber, Charles R., and Walter N. Thurman. "Testing the Theory of Tournaments: An Empirical Analysis of Broiler Production." *Journal of Labor Economics* vol. 12, no. 2. 1994.

Lambert, Richard A., David F. Larcker, and Keith Weigelt. "The Structure of Organizational Incentives." *Administrative Science Quarterly*, 38. 1993.

Lazear, Edward P. (1989) "Pay Equality and Industrial Politics", *Journal of Political Economy* 97: 561-580.

Lazear, Edward P. (1992), "The Job as a Concept", in: W. Bruns, ed., *Performance Measurement, Evaluations, and Incentives*. Harvard University Press. 183-215.

Lazear, Edward P., and Sherwin Rosen. "Rank -Order Tournaments as Optimum Labor Contracts." *Journal of Political Economy* 89 (October 1981): 841-64.

Main, Brian; O'Reilly, Charles; and Wade, James. "Top Executive Pay: Tournament or Teamwork." *Journal of Labor Economics* 11 (October 1993): 606-28.

Malcomson, James M. "Work Incentives, Hierarchy, and Internal Labor Mar kets." *Journal of Political Economy* 92 (June 1984): 486-507.

McLaughlin, Kenneth. "Aspects of Tournament Models: A Survey." In *Research in Labor Economics*, vol. 9, edited by Ronald Ehrenberg, pp. 225-256. Greenwich, CT: JAI, 1988.

Mookherjee, D. (1984) "Optimal Incentive Schemes with Many Agents", *Review of Economic Studies* 51: 433-446.

Nalebuff, Barry J., and Joseph E. Stiglitz. "Prizes and Incentives: Towards a General Theory of Compensation and Competition." *Bell Journal of Economics* 14 (Spring 1983): 21-43.

O'Keeffe, Mary, Kip Viscusi, and Richard J. Zeckhauser. "Economic Contests: Comparative Reward Schemes." *Journal of Labor Economics* 2 (January 1984): 27-56.

O'Reilly, Charles A., Brian G. Main, and Graef S. Crystal (1988). "CEO Compe nsation as Tournament and Social Comparison: A Tale of Two Theories." *Administrative Science Quarterly*, 33: 257-274.

Rosen, Sherwin. "Prizes and Incentives in Elimination Tournaments." *American Economic Review* 76 (September 1986): 701-16.

Waldman, Michael. (2003) "Ex Ante Versus Ex Post Optimal Promotion Rules: The Case of Internal Promotion." *Economic Inquiry* (forthcoming).

Waldman, Michael. (1984) "Job Assignments, Signaling and Efficiency", *Rand Journal of Economics*, 15, 255-270.

Zabojnik, Jan, and Dan Bernhardt. (2001) "Corporate Tournaments, Human Capital Acquisition, and the Firm Size – Wage Relation." *Review of Economic Studies* 68, 693-716.

Table 1: Descriptive Statistics for the Full Sample

	Mean	*Standard Error*
Promotion Variables		
PROMOTE	0.075	0.310
PROMEXP	0.667	0.676
Performance Variables		
Performance (P)	78.337	22.536
Typical Performance (P_0)	76.132	21.377
Worker Characteristics		
More than High School	0.255	0.590
College or more	0.348	0.958
Fraction High Skilled	0.314	0.646
Tenure (months)	6.061	14.976
Firm Characteristics		
For Profit	0.753	0.832
Franchise	0.061	0.325
Number of Sites	62.900	461.403
Size	745.506	13222.282
Union (% covered in firm)	17.538	60.200
Temps	0.355	0.846
Contract	0.297	0.731
Number of Observations	3510	

TABLE 2: Probability of Promotion and Expected Promotion

Dependent Variable	*PROMOTE*		*PROMEXP*	
Performance (P)	0.241 (0.050)**	0.191 (0.049)**	0.362 (0.091)**	0.389 (0.092)**
Typical Performance (P_0)	-0.116 (0.049)**	-0.081 (0.044)*	-0.268 (0.108)**	-0.308 (0.113)**
Worker Characteristics				
More than High School	•	-0.290 (1.272)	•	-0.345 (2.938)
College or more	•	-5.507 (1.399)**	•	2.217 (3.927)
Fraction High Skilled	•	0.932 (2.484)	•	10.405 (5.372)*
Tenure	•	0.333 (0.066)**	•	-0.804 (0.177)**
Firm Characteristics				
For Profit	•	4.043 (1.261)**	•	16.501 (4.650)**
Franchise	•	-0.549 (2.009)	•	-0.767 (5.761)
Number of Sites	•	0.232 (1.280)	•	7.960 (4.770)*
Size	•	-0.833 (0.652)	•	7.720 (3.370)**
Union	•	-0.041 (0.019)**	•	-0.128 (0.055)**
Temps	•	-0.115 (1.296)	•	8.728 (3.176)**
Contract	•	0.171 (1.383)	•	-0.412 (3.240)
N	2721	1960	2335	1833
Pseudo R^2	0.0229	0.1218	0.0098	0.0768

Notes: Reported coefficients are probability derivatives (dF/dX) evaluated at the means and multiplied by 100. Standard errors are in parentheses and are also multiplied by 100. * and ** indicate significance at the 10% and 5% levels, respectively. Coefficients and standard errors for Number of Sites and Size are also further multiplied by 1000.

Table 3: Descriptive Statistics for Professionals

	Mean	*Standard Error*
Promotion Variable		
PROM	0.573	0.840
Performance Variable		
Performance (P)	81.199	21.853
Performance of Competition		
Typical Performance (P_0)	77.466	23.106
Wage Spread		
Hourly wage difference (S)	5.835	17.185
Worker Characteristics		
More than High School	0.166	0.505
College or more	0.731	0.619
Fraction High Skilled	0.496	0.513
Tenure (months)	6.448	16.094
Firm Characteristics		
For Profit	0.593	0.854
Franchise	0.048	0.378
Number of Sites	65.695	453.711
Size	1712.825	20640.040
Union	21.784	72.540
Temps	0.454	0.855
Contract	0.399	0.820
Number of Observations	520	

Table 4: Estimates from Structural Tournament Model

	P	*S*	*PROM*[*]
S (wage spread)	-0.222 (0.174)	•	•
Worker Characteristics			
More than HS	-0.010 (0.042)	-0.114 (0.097)	-0.271 (0.280)
College or more	0.010 (0.034)	0.050 (0.092)	-0.259 (0.268)
Fraction high skilled	0.085 (0.041)**	-0.010 (0.113)	0.051 (0.304)
Tenure	0.016 (0.019)	0.075 (0.039)*	0.187 (0.109)*
Firm Characteristics			
For Profit	•	0.023 (0.065)	-0.380 (0.219)*
Franchise	•	-0.100 (0.131)	0.175 (0.402)
Number of Sites	•	-0.000 (0.000)	-0.001 (0.001)
Size	•	0.011 (0.016)	-0.009 (0.055)
Union	•	0.002 (0.001)*	0.005 (0.003)*
Temporary	•	0.013 (0.059)	-0.089 (0.198)
Contract	•	-0.103 (0.064)	-0.025 (0.205)
Performance of Typical Employee	•	•	1.630 (0.818)**
Constant	0.840 (0.071)**	0.360 (0.108)**	-0.549 (0.713)
Ó$_{11}$		0.030 (0.016)*	
Ó$_{22}$		0.214 (0.021)**	
Ó$_{12}$		0.046 (0.038)	
Ó$_{1v}$		-0.000 (0.000)*	
Ó$_{2v}$		-0.000 (0.000)	

Note: Asymptotic standard errors are in parentheses. ** and * indicate significance at the 5% and 10% levels, respectively.